



Big Data in the Health and Life Sciences

What Are the Challenges for European Competition Law and Where Can They Be Found?

Minssen, Timo; Schovsbo, Jens Hemmingsen

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Intellectual Property and Digital Trade in the Age of Artificial Intelligence and Big Data

Edited by Xavier Seuba, Christophe Geiger, and Julien Pénin

With contributions by

Keith E. Maskus, Yann Ménière, Ilja Rudyk, Sean M. O'Connor, Catalina Martínez, Peter Bittner, Alissa Zeller, Reto Hilty, Christophe Geiger, Giancarlo Frosio, Oleksandr Bulayenko, Ryan Abbott, Timo Minssen, Jens Schovsbo, Francesco Lissoni, Gabriele Cristelli, and Claudia Jamin



International Centre for Trade
and Sustainable Development



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Abbreviations

3D	three-dimensional
4IR	fourth industrial revolution
5G	fifth-generation
AI	artificial intelligence
BETA	Bureau of Theoretical and Applied Economics
CAFC	Court of Appeals for the Federal Circuit
CEIPI	Center for International Intellectual Property Studies
CII	computer-implemented invention
CJEU	Court of Justice of the European Union
CPS	cyber-physical system
CPU	central processing unit
DOS	disk operating system
DRM	digital rights management
DSM	digital single market
EPC	European Patent Convention
EPO	European Patent Office
EU	European Union
EULA	end-user licence agreement
FTO	freedom to operate
G20	Group of 20 (advanced and emerging economies)
GDP	gross domestic product
GDPR	General Data Protection Regulation
GUI	graphical user interface
I3PM	International Institute for Intellectual Property Management
ICT	information and communications technology
ICTSD	International Centre for Trade and Sustainable Development
IP	intellectual property
IPC	international patent classification
IPR	intellectual property right
IT	information technology
LOT	License on Transfer
OECD	Organisation for Economic Co-operation and Development
OSS	open source software
PATSTAT	Worldwide Patent Statistical Database
PCT	Patent Cooperation Treaty
R&D	research and development
RAM	random active memory
SaaS	software as a service
TDM	text and data mining
TFEU	Treaty on the Functioning of the European Union
TRIPS	Trade-Related Aspects of Intellectual Property Rights
USPTO	United States Patent and Trademark Office
WIPO	World Intellectual Property Organization

Foreword

The Center for International Intellectual Property Studies (CEIPI) and the International Centre for Trade and Sustainable Development (ICTSD) are pleased to present the fifth issue of the publication series on Global Perspectives and Challenges for the Intellectual Property System. This issue continues to develop what the publication series intends to provide: high-quality academic and policy-oriented papers dealing with topics that are of global importance because of their normative pre-eminence, economic relevance, and socioeconomic impact.

CEIPI and ICTSD decided to launch this common project convinced by the synergies existing between both organisations. We share a common interest in intellectual property (IP) as a tool for innovation, development, and the pursuit of broader societal interests, being profoundly engaged in knowledgeable and informed reflection and international debates touching upon how intellectual property can fulfil these important goals. This series of papers aims, therefore, at provoking consideration of contemporary issues thanks to the collaboration of recognised scholars and experts, giving voice to them, enriching the academic debate, and feeding policymakers with high-quality materials.

The series wishes to reach a broader audience, ranging from academics to public officials, including civil society, experts, business advisers, and the broad membership of the IP community. We also have in mind the actual implementation of IP—how IP works in practice—without losing sight of public policy objectives, including its intersection with innovation, creativity, and sustainable development goals.

We sincerely hope you will find this fifth issue of the series, dealing with IP and digital trade in the age of artificial intelligence and big data, a useful contribution to a better understanding of the legal complexities and social and economic opportunities arising from technologies that lay the groundwork or foundation for a new industrial revolution.



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Introduction

Xavier Seuba, Christophe Geiger, and Julien Penin

The origin of this publication was the conference “Intellectual property and digitalization: challenges for intellectual property management,” organised in May 2017 by the Center for International Intellectual Property Studies (CEIPI), the Bureau of Theoretical and Applied Economics (BETA), and the International Institute for Intellectual Property Management (I3PM). The objective of the conference was to shed light on the most recent evolution in intellectual property brought by digitalisation, gathering an eclectic group of experts from academia, public institutions, and industry. From an academic standpoint, we were particularly interested in combining law, economics, and management scholars.

Such an ambition is not new at the University of Strasbourg. The CEIPI–BETA project in law and economics of intellectual property was launched in 2013, becoming the first joint research initiative of two constituent bodies of the University of Strasbourg, made up by law and economics scholars. Seminars, workshops, publications, and conferences have been possible since then thanks to the interaction of both groups of scholars and the generous support of Air Liquide and Total. This publication is an outcome of the CEIPI–BETA project in law and economics of intellectual property.

The interest in partnership and cooperation between our law and economics research centres mirrors the central place that the relationship between law and economics has acquired in current debates and initiatives on innovation and competition. This has been complemented by an increasing presence of chief economists in the most relevant intellectual property institutions, including the World Intellectual Property Organization, the European Patent Office (EPO), the European Union Intellectual Property Office, and several national institutions.

The growing relevance of the economics of intellectual property is partially explained because analysis by economists helps to contextualise the function that intellectual property rights fulfil. In this respect, economic analysis allows us to put intellectual property in relation to the achievement of socially desirable goals, such as employment, innovation, and creativity. It also helps to objectivise certain claims to broaden (or, sometimes, shorten) intellectual property protection by empirical findings, thus participating in what scholars increasingly refer to as necessary “evidence-based intellectual property protection,” adding significantly to a policy context often characterised by polarised discussions and confrontations of a sometimes ideological nature.¹ At the same time, an economically relevant outcome may not always be legally acceptable. This has been illustrated clearly by economic studies showing both negative and positive externalities of intellectual property infringement. Thus, while economics guides law, law also shapes economics and embraces values that go beyond economic output or rationales.² Naturally, this interface creates a very interesting space for policy discussion and legal reform, and informs legislators embracing data-driven policymaking.

This is the context in which the CEIPI–BETA project in the law and economics of intellectual property was launched, with three central objectives in mind: to stimulate cooperation between economists and legal scholars; to become a forum for discussion; and to develop research capacity. The areas of research

1 See, for example, Jeremy de Beer, “Evidence-Based Intellectual Property Policymaking: An Integrated Review of Methods and Conclusions,” *Journal of World Intellectual Property* 19.5–6 (2016): 150. In the European context, see Christophe Geiger, “Moving Out of the Economic Crisis: What Role and Shape for Intellectual Property Rights in the European Union?” in Harri Kalimo and Max S. Jansson (eds), *EU Economic Law in a Time of Crisis* (Cheltenham, UK and Northampton, MA: Edward Elgar, 2016), 148, stating that in order to be fully legitimised, “future initiatives by the European legislature will have to be based appropriately on serious and above all independent economic data and impact assessments that make it possible to measure the probable consequences of the legislative activity.”

2 See, for example, Xavier Seuba, “The Economics of Intellectual Property Enforcement,” *World Intellectual Property Organization Journal* 6.2 (2015): 133–142.

interest identified since the beginning of the CEIPI–BETA project include two topics of relevance for this publication—intellectual property management, and intellectual property and digitalisation. In this publication, we aim to prompt discussion on a highly topical issue thanks to the chapters submitted by professionals with very different backgrounds. This is indeed riskier than delivering a publication with only legal scholars, or with only economists or industry representatives. The mix of policy, academic, and industrial backgrounds helps to reflect on current complexities and opportunities.

The chapters compiled here elaborate on changes in modes of innovation, production, and commercialisation of innovation, which are central in current discussions and relate closely to intellectual property law and competition. The snapshot of the current and rapidly evolving technological and economic situation allows authors to elaborate on legal options, economic impact, and policy choices. As things stand right now, there are more questions than answers, amid a generalised perception of being immersed in a sea-change movement and revolutionary times. The contributions we introduce feed the debate, identify the central aspects, and may be instrumental at drafting a research agenda.

Such reflections are crucial to propose a balanced regulative framework for the future and a “human” development to these advances in technology, posing broader ethical and philosophical questions. Needless to say, the economic implications for big data and artificial intelligence in the near future are immense. The market for artificial intelligence is predicted to grow to more than US\$ 47 billion in 2020. China has declared artificial intelligence a national priority, with huge investments made by the Chinese government. These investments are generating legitimate claims for protection. This is complicated by the fact that in “the Fourth Revolution,” to quote a recent study drafted by Chief Economist Yann Ménière and his team at the EPO,³ machines will also be able to act as innovators and creators. At the same time, the intellectual property system has its rationales and balances, and we need to be careful not to turn the entire system upside down too quickly, as this can have unforeseen consequences.⁴ Similar issues were experienced with the extension of patent law in the field of software and business methods, which has provoked tensions and strong rejections in the public opinion.⁵

This publication contains two largely interdependent parts. Part One: From Digital Trade to Commercialisation and Management of Intellectual Property includes contributions by Keith E. Maskus, Yann Ménière and Ilja Rudyk, Sean M. O’Connor, Catalina Martínez, Peter Bittner, and Alissa Zeller.

Keith E. Maskus holds that in order to foster innovation in digital technologies and trade, it is vital to set up with a dynamic technology policy that encourages innovation and business experimentation. In this regard, fiscal supports for research and development spending are a satisfactory measure if they are generally available. Public support for a robust, universally accessible, and dynamic internet remains key to further advancement. Another important component of support is an infrastructure policy that emphasises universal and efficient connectivity with the platform. In this regard, ensuring seamless interoperability across users and content providers is key. Maskus also notes that a change may be needed in respect to the traditionally light regulatory approach and relatively soft penalties in the

3 Yann Ménière, Ilja Rudyk, and Javier Valdes, *Patents and the Fourth Industrial Revolution: The Inventions Behind Digital Transformations* (Munich: European Patent Office, 2017). See also the chapter by Yann Ménière and Ilja Rudyk in this publication.

4 On this crucial issue, see Christophe Geiger, “The Social Function of Intellectual Property Rights, Or How Ethics Can Influence the Shape and Use of IP Law,” in G.B. Dinwoodie (ed.), *Methods and Perspectives in Intellectual Property* (Cheltenham, UK and Northampton, MA: Edward Elgar, 2013), 153.

5 On this issue, see the chapter by Catalina Martínez in this publication.

context of liability rules for internet service providers and social media, in order to respond to evolving and current complexities. International cooperation in this regard may be key in the next stages of digital trade regulation. The promotion of trade and innovation in digital technologies also requires that goods and services sold online can transit easily across national borders. Restrictions on such trade arise from requirements for data localisation, mandates for local processing of data, or requirements for government approval for data transfers. Protection of privacy, enhancement of cyber-security, and advancement of technology transfer are usually invoked to justify those measures, which may also entail disguised restrictions to trade. Maskus holds that barriers to trade in data generate substantial costs in efficiency and associated welfare losses. In that context, European Union (EU) efforts to harmonise privacy protection, commercial exploitation of data, and the elimination of barriers to erect a single market are of particular interest and uncertain success. More broadly, increasing international tensions over cyber-security and data privacy challenge conventional thinking regarding the development of dynamic technological markets.

Yann Ménière and Ilja Rudyk address patentability trends at the EPO regarding computer-implemented technologies that enable the "fourth industrial revolution" (4IR), focusing on autonomous, connected objects. They rely on a recent study released by the EPO, which emphasises both the potential of the 4IR in many different sectors and its speedy development. The data analysed confirm the rise of the Republic of Korea and some Asian economies, but also the relevant contribution of the European economy to digital economy in its most sophisticated forms. Examination practices regarding computer-implemented technologies are briefly introduced, as well as the managerial and institutional reforms undertaken to cope with the rise of 4IR-related technologies, concluding that the examination practices, the legal framework, and the measures taken to manage new applications allow the EPO to "provide legally robust patent rights of the highest quality to applicants and innovators around the world."

Sean M. O'Connor touches on innovation in business models and introduces the range of digital business models clustered around three basic concepts: the traditional sales model, the licence model (digital artefacts conveyed on physical media), and the delivery of digital artefacts as services. O'Connor advocates a flexible regulatory environment and argues that the same regulatory flexibility that legal regimes governing technological hubs give to exploration of commercialising new technologies should apply with regard to innovative business and legal models. In a related fashion, he defends heightened scrutiny of user contracts. In this respect, O'Connor emphasises that the gap between the marketed rights and the actual legal rights conveyed can be tremendous. A partial solution is heightened judicial scrutiny of terms of service and privacy policies when issues arise. Another proposal put forward by O'Connor consists of putting consumers centre-stage and promoting the standardisation of contract elements (but not the entire agreement) and truth-in-disclosure rules.

Patentability of software and its impact on innovation are addressed by Catalina Martínez. Drawing on economic analysis, her chapter underlines that patenting may not always be needed to recoup the costs of investing in software development. In a related fashion, she claims that it is difficult to assess what part of the growth in software-related patent applications responds to increased innovation and what part is just a consequence of higher patent propensity in the field. Importantly, Martínez puts forward three recommendations to patent offices, for all patents in general, and more so for software-related inventions. The first recommendation is to increase transparency about the legal status of patents and their owners. Second, Martínez recommends maintaining a high inventive step and strict non-

obviousness test, in order to stop the grant of trivial patents. Finally, she underlines that it is necessary to ensure that all patent filings include sufficient information on how to implement the invention, so that patents are granted not to an "idea" or a "desideratum" but to inventions that can be implemented and help solve well-identified problems.

Peter Bittner describes how the digital transformation impacts daily life and identifies key enablers of the digital transformation. Technologies that rely on the existence of multiple technology layers communicate through the Internet of Things. These technologies boost advanced innovation, such as autonomous automobile systems and interconnected medical monitoring devices. The Internet of Things allows objects to be sensed or controlled remotely across existing network infrastructure, creating opportunities for integration of the physical world into computer-based systems. A central aspect of Bittner's chapter are the intellectual property management challenges arising from the intangible nature of software and data. As Bittner explains, modern software solutions often show a distributed character in that different parts of the software may be executed by different devices operated by different parties in different countries. In this context, a critical question is who should own what and where. In addition to data ownership concerns, Bittner addresses how the digital transformation impacts old paradigms of exclusivity or freedom to operate (FTO). When looking at intellectual property generated for complex layered technologies, it is unusual for a new software solution to go to market without infringing a large number of patents in the various technology layers. Hence, it would seem that the primary use of intellectual property should move from excluding others to improving the bargaining power of rights-holders.

Alissa Zeller underlines that digitalisation has reached all sectors of the chemical industry, and that it is time to implement digital intellectual property strategies. In this regard, she underlines that the numbers relating to information technology (IT) patents filed by chemical companies are still negligible when compared with IT patents in industries that entered the digital world earlier. Patent protection strategies have differed between the chemical and the IT sectors. For chemical products, an in-depth FTO analysis can be done because of the defined product (chemical formula) and the limited number of patents per product. This is not the case for IT inventions, in particular because of the large number of patents and the lack of a standardised technical terminology. FTO processes in the chemical industry are impacted by digitalisation at both ends of the product development: at the front end, the selection of ideas for further development will be facilitated by big data analysis. At the back end, digitalisation introduces new FTO complexity. An increasing number of projects will include not only chemical inventions but also associated IT innovations. Accordingly, both a "classic" FTO and a risk-based FTO—including licensing options—will be necessary. Artificial intelligence and big data are the digital backbone technologies of new software supporting the search specialist and patent lawyer. There are already tools for white space analysis, and development is under way for intelligent analysis of invalidity, infringement, and enforcement. Zeller raises important questions, including those relating to the legal relevance of computer-generated mass-patent filings covering computer-identified white space spots. Will such patent applications count as prior art? Will they be patentable? Who is the respective inventor?

Part Two: Regulating and Using Big Data in the Digital World includes contributions by Reto Hilty, Christophe Geiger, Giancarlo Frosio, and Oleksandr Bulayenko, Ryan Abbott, Timo Minssen and Jens Schovsbo, Francesco Lissoni and Gabriele Cristelli, and Claudia Jamin.

Reto Hilty contextualises the current centrality of big data in a longer and ongoing industrial revolution that started in the middle of the twentieth century. Data processing, data storage, and data transportation were central elements in previous moments of such industrial revolution. The crucial difference is now found in the volume and nature of data, which have become part of the infrastructure of the digital economy, the so-called “data-driven economy.” There is hence particular reason—the public infrastructure nature of data—for public authorities to be concerned about data. Hilty focuses on the action undertaken by the European Commission in this domain and identifies, as the central question that needs to be answered, whether legislation is actually needed. As Hilty underlines, the data-driven economy is prospering with virtually no (specific) legislation. While he analyses several relevant aspects, two guiding principles can be underlined. First, a one-size-fits-all approach is not likely to produce positive effects at large. Second, generally, simple *de*-regulation might be the right answer to further stimulate initiatives in the data-driven economy. Prudence in the regulation, and in particular in the granting of exclusive rights over data, is the main recommendation he puts forward.

Christophe Geiger, Giancarlo Frosio, and Oleksandr Bulayenko underline that although artificial intelligence, neural networks, and machine learning, through the exploitation of big data streams made available by digital networking technology, might be set to become the most disruptive technologies in the years to come, they bring about a set of thorny legal challenges. These artificial intelligence learning processes must use inputs possibly protected by intellectual property rights to create wholly transformative outputs. Text and data mining (TDM) has been a fundamental technique to make machine learning—and artificial intelligence autonomous decision-making and creativity—possible by copying or crawling massive datasets. The EU has been struggling for some time on whether TDM techniques should be considered within the reach of copyright and other *sui generis* rights or whether they should be exempted from that reach. To the end of bringing clarity to a confused panorama of possible applicable exceptions and limitations to TDM activities, the European Commission’s proposal for a directive on copyright in the digital single market would like to introduce a specific exception. Of course, the new exception will facilitate research and innovation in the digital single market by bringing about long-sought harmonisation. Its narrow scope, however, will limit these substantive positive externalities to a comparatively small number of research institutions, while the digital single market at large will still lag behind other jurisdictions, allowing a larger cluster of market players to legally engage in TDM activities.

Ryan Abbott analyses how intellectual property should adapt to innovation generated by computers. He emphasises that computers are doing more than ever before, and their work goes far beyond manual labour. Not only doctors, lawyers, and scientists, but also inventors, can be partially replaced by computers. In this respect, Abbott’s contribution launches a challenging proposition, namely to recognise computers as true inventors. Abbott holds that this recognition will functionally produce more innovation because it will incentivise the development of creative computers. Acknowledging computers as inventors would reward effort upstream of the stage of invention and promote disclosure and commercialisation of patentable subject matter. There are two preliminary barriers for that purpose: the reference to the individual to describe the inventor, and the characterisation of the invention as a “mental act.” Traditional patent law principles militate against the granting of patents if these circumstances do not concur. While some computers generate output in a process akin to a person’s mental act, the central argument by Abbott is found elsewhere: we should care functionally

about whether the system generates innovation, not how innovation occurs. Ownership, however, should not be for the "innovator-computer." Instead, Abbott defends that the computer's owner should be the automatic assignee of anything the computer develops.

The relevance of big data is not limited to applications in the information technology sector but extends to other important technological fields, such as the increasingly data-driven health and life sciences. Timo Minssen and Jens Schovsbo introduce some of the challenges resulting from the intersection between big data and competition law in health and life sciences. With a focus on European competition law, they describe the increasing relevance of big data and the protection of data in health and life sciences, how these developments relate to European competition law, and what and where the main challenges are. Minssen and Schovsbo consider imperative that the legal issues raised by big data and artificial intelligence are given the highest priority by the European Commission, and they welcome that the Commission devotes efforts and resources to address competition aspects of big data and privacy in order to test whether its jurisdictional criteria are still adequate.

Inventors are an important class of knowledge workers, especially in sectors where research and development is a key innovation input. Francesco Lissoni and Gabriele Cristelli underline that economic research on patent inventors has co-evolved with data availability. On the one hand, economic research has exploited the increasing amount of data made available to social scientists by intellectual property authorities; on the other hand, it has also contributed greatly to steering the data diffusion process, both by soliciting more information and by pioneering new methods for treating and validating it. By doing so, economic research has raised some substantive issues on the quality of inventor information as reported by patent applicants, which deserve the attention of both intellectual property authorities and legal scholars. Lissoni and Cristelli provide an overview of such evolution and questions, touching on the main findings and technical issues highlighted by the scholarly community over the past decades.

Claudia Jamin uses the example of Asea Brown Boveri (ABB) to underline that various stakeholders perform different tasks in the overall setup of data flows and processes, and all those stakeholders share the interest in big data. Ownership of data is central in that context. According to Jamin, an important problem is that the legislative environment remains inconsistent and cannot provide resilient solutions to secure the enormous investments by companies in the new big data-based technologies. Jamin explores the possibilities that copyright protection gives, but the concepts of author and originality, as well as territorial scope of protection, do not match well with the production and functioning of big data. The problem arising from (lack of) originality also emerges when protection of big data is proposed through database protection. In the case of trade secrets, Jamin underlines the difficulty of preserving secrecy for multinational enterprises operating and serving customers around the globe. All in all, "consistent and resilient solutions of data protection and ownership are missing." For Jamin, current intellectual property rights may be incidentally helpful, but the legal environment remains insecure for companies investing in the development of new technologies.

PART ONE

From Digital Trade to Commercialisation and Management of Intellectual Property

Fostering Innovation in Digital Trade

Keith E. Maskus

1. Introduction*

The concept of digital trade encompasses the marketing and cross-border sale of both physical and virtual goods on the internet. Physical goods require some delivery mechanism but can be readily purchased online. Digital trade has the potential to be one of the most dynamic and innovative platforms for creative entrepreneurs and small enterprises to develop international marketing networks and increase sales. One simple measure of this dynamism is that the vast majority of firms in the United States engaged in traditional international merchandise trade sell only to one or two foreign markets, with just a few of the largest enterprises accounting for over 95 percent of goods exports.¹ In contrast, according to eBay officials who monitor such flows, the majority of small suppliers using their service export to 15 or more countries.² There are many reasons for such differences, of course, beginning with the fact that the latter firms generally sell individualised commodities that may be easily shipped, rather than large volumes of bulk goods. However, this anecdote does suggest that digital trade offers a simple and low-cost means of entering foreign markets more cheaply than by traditional processes. It also points out that access to global e-commerce is among the most inclusive forms of international trade, for it invites participation by individual entrepreneurs and start-ups, in both goods and services.

Moreover, digital trade has the potential to help struggling firms become more productive and efficient by offering inexpensive services that can cut costs. Consider, for example, the potential for online translation programs, such as Google Translate, to facilitate lower-cost contracting and billing across countries as its precision increases. Digitally traded services are also poised in the medium term to transform core elements of numerous service sectors that may currently be outdated and inefficient, such as public services, higher education, and healthcare. Online platforms offer the potential for widely distributing both supplier tasks and user networks across geographical regions and diverse groups to previously unattainable degrees.

Finally, it goes almost without saying that beyond basic e-commerce, the world is just beginning to understand the breadth and depth of digital services that will be traded across borders to facilitate growing new industries, such as autonomous driving vehicles, smart metering technologies, wearable smart fabrics, and the Internet of Things. Countries and firms that are poised to build the electronic infrastructure for such activities and facilitate the development of e-commerce markets and digital trade routes will be their major beneficiaries.

In this chapter I offer some thoughts, based in part on my experience as a US government official, on policy frameworks that might either encourage or discourage the development of such opportunities and innovation. The issues are complex and offer multiple trade-offs to consider. Ultimately, however, I argue that countries should seek to develop supporting frameworks that facilitate entrepreneurship and creativity, while offering low-cost access to international digital markets, which may be mediated

* This chapter is based on remarks made at the CEIPI conference "Intellectual Property and Digitalization: Challenges for Intellectual Property Management," University of Strasbourg, May 2017. At that time the author was the Chief Economist of the US State Department, an appointment that has since ended. The views expressed here are strictly those of the author and do not necessarily reflect those of the State Department.

1 Andrew B. Bernard, J. Bradford Jensen, Stephen J. Redding, and Peter K. Schott, "Firms in International Trade," *Journal of Economic Perspectives* 21 (2007): 105–130.

2 Author's conversation with eBay official, March 2017.

by internationally integrated digital service suppliers. In this context, seamless international connectivity is the goal, even as there may be political and economic costs in achieving it. I also point out the need for additional research in order to increase our understanding of the complexities in building international digital markets.

2. Data and Digital Trade: Critical Inputs for Dynamic Economies

Digital trade, which may be defined as domestic commerce and international trade conducted over the internet, is an important contributor to economic activity. While activity from such commerce itself is significant, internet-based technologies also facilitate growth through increasing productivity and cutting transaction costs in trade. The United States International Trade Commission estimates that such technological improvements expanded US gross domestic product (GDP) by 3.4–4.8 percent in 2011.³ They also expanded real wages by around 4.5–5 percent and raised US employment by 2.4 million full-time equivalent jobs. US digitally intensive firms sold nearly US\$ 1 trillion in goods and services online in 2012, while purchasing almost US\$ 500 billion in goods and services. About a quarter of these transactions were performed by small and medium-sized enterprises. A recent consulting report claims that digital trade contributes as much to global economic growth as does traditional trade in merchandise.⁴

The Organisation for Economic Co-operation and Development (OECD) has also offered some estimates of the size of the internet-based economy.⁵ Using 2011 data, the OECD reckoned that internet-related activities amounted to around 13 percent of business value added. The internet was forecast to contribute 5.3 percent of the combined GDP of members of the G20, and 5.7 percent of the GDP of the European Union (EU), in 2016.⁶ For its part, the European Commission sustains a monitoring project to track growth of the digital economy within the EU.⁷ It estimates that the value of the EU data economy was around €300 billion in 2016, expected to rise to €739 billion by 2020. Employment in the data sector was 6.16 million in 2016, and there were some 255,000 data-oriented companies in the sector.

Note that these latter studies adopt narrow definitions of the digital economy, focusing strongly on the collection and use of data and internet transactions. A broader definition might include important content industries, such as software and digital publishing, music, and entertainment. These broader concepts point to increasing importance and dynamism in the digital area, particularly as mediated by the internet. For example, the World Intellectual Property Organization produces studies for its member countries of the contribution of

3 United States International Trade Commission, *Digital Trade in the US and Global Economies: Part 2*, Publication No. 4485, August 2014.

4 Susan Lund, *Digital Protectionism and Barriers to International Data Flows* (Washington, DC: McKinsey Global Institute, 2016).

5 Organisation for Economic Co-operation and Development, "Measuring the Internet Economy: A Contribution to the Research Agenda," OECD Digital Economy Papers No. 226 (Paris: Organisation for Economic Co-operation and Development, 2013).

6 David Dean, Sebastian Digrande, Dominic Field, Andreas Lundmark, James O'Day, John Pineda, and Paul Zwillenberg, *The Internet Economy in the G-20: The \$4.2 Trillion Growth Opportunity* (Boston, MA: Boston Consulting Group, 2012).

7 European Commission, *The European Data Market Study: Final Report* (Brussels: European Commission, 2017).

copyright-based sectors, including digital goods and services, to their respective GDPs. In France, for example, value added in copyright industries in 2012 amounted to over 7 percent of GDP and accounted for 7.3 percent of full-time employment.⁸

That data have economic value at the macroeconomic level is mirrored by the fact that they are intensely valuable for firms that generate or collect them online. This value stems largely from the ability of firms to monetise data through selling their characteristics to advertisers. It is estimated that Google's advertising revenue per user was US\$ 45 in early 2014 and US\$ 9.45 for Facebook in the same year.⁹ Each of these companies earned more than 90 percent of its revenue from online advertising. Access to data also permits firms to tailor new products and services to meet the preferences of individual users, raising the value of data even more. The current trend of massive private investments made in constructing databases is additional evidence of the large economic stakes in this sector. As for the EU, it is estimated that applications built on personalised data could provide benefits to its firms and citizens of perhaps €1 trillion annually by 2020.¹⁰

Finally, it is important to note that the value of international trade in digital goods and services is growing rapidly.¹¹ This trade, which involves digitised products and services, data, and physical products bought and sold via e-commerce, is growing two to three times faster than conventional trade between the United States and Europe. Two-way trade is large and growing: the EU takes 45 percent of digitally delivered US service exports, while supplying 46 percent of similar US imports, by far the largest such shares. The Bureau of Economic Analysis of the US Commerce Department publishes figures on digitally enabled international services trade.¹² In 2015, the United States had a US\$ 161.5 billion trade surplus in digitally deliverable services, with US\$ 70 billion of that surplus involving the EU. Much of this digitally enabled trade comprises knowledge-based inputs that go into complex production processes.

3. Building a Supportive Framework

Such figures suggest that digital industries and trade are thriving, at least among the major industrialised economies. However, there remain concerns about structural impediments to innovation and competition in this area, such as cost-raising restrictions on cross-border data flows, differential regulatory systems across countries, including within the EU, and caution about the use of private data for commercial purposes. Because the EU system of data protection and use emanates from differential national systems and preferences, it is more fragmented than that of the United States and, arguably, results in lagging European innovation in this space.

8 World Intellectual Property Organization, *The Economic Contribution of Copyright Industries in France* (Geneva: World Intellectual Property Organization, 2016).

9 Cassandra Liem and Georgios Petropoulos, "The Economic Value of Personal Data for Online Platforms, Firms and Consumers," Bruegel blog post, 14 January 2016, <http://bruegel.org/2016/01/the-economic-value-of-personal-data-for-online-platforms-firms-and-consumers/>.

10 Ibid.

11 Kati Suominen, "Where the Money Is: The Transatlantic Digital Market," Center for Strategic and International Studies blog post, 12 October 2017, <https://www.csis.org/blogs/future-digital-trade-policy-and-role-us-and-uk/where-money-transatlantic-digital-market>.

12 Jessica R. Nicholson, "New BEA Estimates of International Trade in Digitally Enabled Services," Economics and Statistics Administration, US Department of Commerce, 24 May 2016, <http://www.esa.doc.gov/economic-briefings/new-bea-estimates-international-trade-digitally-enabled-services>.

Such concerns underlie the ongoing attempts to build a digital single market across EU members.¹³ This is a massive and complex undertaking, spanning numerous areas of policy and regulation, innovation, and competition. Rather than try to address this complexity in this short chapter, a task that I am not qualified to perform in any event, I use this section to set out thoughts about which basic framework conditions seem to be most suitable for fostering innovation in digital technologies and trade. What seem to be the primary factors supporting creativity in cross-border digital trade? This discussion inevitably focuses on the recent history of such dynamism in the United States, with which I am most familiar. While instructive, it may not be fully applicable to conditions in the EU or elsewhere, where attitudes towards data regulation sometimes differ sharply.

A primary supporting condition is the existence of a dynamic technology policy that encourages innovation and business experimentation. There are solid arguments for fiscal supports for research and development spending, for example, whether through tax advantages or cost-sharing, so long as that support is generally available, rather than specific to firms, and addresses information market failures that diminish innovation incentives.¹⁴ In this context, public support for a robust, universally accessible, and dynamic internet that readily adopts new technologies remains key to further advancement. Indeed, the internet is an excellent example of a platform technology that facilitates growth of both large and small applied innovations. This point is particularly relevant in the context of small firms and entrepreneurs seeking to build international brands and markets through digital trade. Such participants exemplify the notion of "self-discovery" in business and economic development as they experiment with market niches and business models.¹⁵

An important component of support is an infrastructure policy that emphasises universal and efficient connectivity with the platform. In this regard, infrastructure goes beyond the needed, and rapidly evolving, information and communication technologies to ensuring seamless interoperability across users and content providers. One source of relative US success in the growth of e-commerce and digital trade is strong competition among internet service providers, search engines, payments systems, and content developers, each with ready access to the technologies necessary for building interoperable markets. That competition has contributed to widespread use of the internet, despite the costs of switching among certain services. Nonetheless, the United States still has work to accomplish in terms of extending such services at high speeds throughout underserved rural areas. As will be discussed, interoperability at the international level remains an important objective in spurring growth in digital trade.

A third important factor relates to liability rules facing internet service providers and such social media as YouTube and Facebook in the display of copyrighted digital products and defamatory and offensive materials, as posted by users. In the evolution of its laws, the United States generally has

13 See European Commission, "Staff Working Document on the Mid-Term Review on the Implementation of the Digital Single Market Strategy: A Connected Digital Single Market for All," SWD(2017) 155 Final (Brussels: European Commission, 2017).

14 Keith E. Maskus and Kamal Saggi, *Global Innovation Networks and Their Implications for the Multilateral Trading System* (Geneva: E15 Initiative, International Center for Trade and Sustainable Development, 2013).

15 Ricardo Hausmann and Dani Rodrik, "Economic Development as Self-Discovery," *Journal of Development Economics* 72 (2003): 603–633; and Dominique Foray, "Smart Specialization and the New Industrial Policy," Policy Brief No. 8 (Brussels: European Commission, 2013).

opted for a light regulatory touch in this context, largely exempting these services from liability so long as they agree to take down infringing material with sufficient and timely notice from rights-holders. Again, this approach helped build an online business environment emphasising innovation and self-determined responsibility by intermediaries. Nonetheless, increasingly complex and difficult challenges continue to emerge, ranging from the posting of illegal materials to the verification of the legitimacy of content origin.¹⁶ This situation currently dominates discussion of third-party manipulation of social media, exemplified by evident Russian intervention in elections abroad, suggesting that more interventionist regulatory systems may be coming, even in the United States. This is an area that seems ripe for international cooperation in the next stages of internet and digital trade regulation.

An additional supporting condition is the ease with which goods and services, sold online, can actually transit across national borders as exports. There are significant trade barriers, postal costs and differences in postal regulations, and other factors that raise both the fixed and variable costs of shipping goods, reducing the effectiveness of international e-commerce. Indeed, such costs can make international sales impossible for small firms and artisans. Evidence shows that the efficiency gains from reducing such barriers, even those as simple as postage costs and access to international mail for delivering packages, are large and growing.¹⁷ This policy complementarity between internet provision to innovators and the physical ability to ship orders is an issue that should be of particular priority for developing and emerging economies.

Finally, the protection of digital copyrights looms large as a factor that can facilitate or impede the smooth functioning of e-commerce and digital trade. Innovation and creativity, both before and in the process of digital trade, are complex and multifaceted processes that depend on an ecosystem of incentives and opportunities.¹⁸ Copyrights sustain incentives to invest in creativity and build markets, particularly important in digital content. They facilitate contracts in which various contributors to creative digital products and services can share income and ownership. They also facilitate licensing and distribution across international markets.

To be effective, copyright systems need to strike a delicate balance between the rights of rights-holders and the needs of users, particularly where the latter may improve upon content to develop creative new applications and expressions. In this regard, the United States may be criticised reasonably for pursuing systems that tilt strongly towards content providers and rights-holders, which have raised costs for libraries and educational users, and creating strong rights to control access to data.¹⁹ Properly balancing incentives for creation and innovation with the needs for widespread access is especially difficult in digital industries, raising a fundamental challenge. Nonetheless, transparent and clear rights to manage content remain a primary incentive for further development of digital trade.

16 Adam Holland, Chris Bavitz, Jeff Hermes, Andy Sellars, Ryan Budish, Michael Lambert, and Nick Decoster, *NoC Online Intermediaries Case Studies Series: Intermediary Liability in the United States* (Cambridge, MA: Berkman Center for Internet and Society, 2015).

17 Christian Volpe Martincus, *Out of the Border Labyrinth: An Assessment of Trade Facilitation Initiatives in Latin America and the Caribbean* (Washington, DC: Inter-American Development Bank, 2016).

18 Keith E. Maskus, *Private Rights and Public Problems: The Economics of Global Intellectual Property in the 21st Century* (Washington, DC: Peterson Institute for International Economics, 2012).

19 Ibid.

4. Digital Trade Protection via Data Regulation

Improving interoperability and access while reducing the costs of trade is clearly important. Arguably more significant, however, is the need to reduce or eliminate costly barriers to cross-border trade in data and data services. Restrictions on this trade arise from, among other regulations, requirements for data localisation, mandates for local processing of data, or requiring government approval for data transfers. Such rules are generally justified as necessary for sustaining privacy and cybersecurity. Countries also enact laws that are discriminatory in their treatment of foreign data suppliers. Among other reasons, this strategy may be seen as a means of forcing international data firms to locate facilities or transfer technology to local licensees. More simply, it may be advocated as a way of temporarily protecting domestic data-based enterprises while they grow and seek to become regional or international powers in data generation and use.

These barriers to trade in data generate substantial costs in efficiency and associated welfare losses.²⁰ These costs are particularly significant for smaller firms, which may face higher costs of data storage and use with localised rather than globalised service providers. They also disrupt the seamless flow of information among related enterprises in production networks. At the same time, there is little evidence that they make data more secure in comparison with corresponding rules placed on data firms as a whole, permitting them to choose where their servers reside.²¹

Recognising such difficulties, the EU is in the process of constructing a complex set of regulations establishing and supporting the digital single market (DSM), among the most important structural policies currently in train.²² The DSM would seek to make data fully transferable within the EU, in essence a "fifth freedom" of movement. Evidence suggests that some parts of Europe lag behind the United States in internet usage and access to digital services, while EU-based data firms are smaller and less integrated than such massive American counterparts as Facebook, Microsoft, Amazon, and Google. In part, these problems are attributable to the existing fragmentation of data services across the region. Accordingly, establishing the DSM is a significant step in Europe's digital future.

Regulations and directives put forward in the DSM are the EU's prerogative, and considerable progress has been made in accelerating integration. The European Commission has expressed a desire to reduce unjustified restrictions on intra-EU data flows, which could usefully limit data barriers, particularly costly localisation requirements. Also promising are proposals to help build a more seamless data economy, facilitating data ownership and access, while encouraging portability and interoperability across borders. Such proposals bear considerable promise to enhance efficiency, reduce costs, and increase well-being within the EU. At the same time, there remain concerns about whether proposed rules to limit so-called "geo-blocking" of content across national markets may be an unwarranted limitation of copyrights in the EU.

20 Matthias Bauer, Hosuk Lee-Makiyama, Erik Van der Marel, and Bert Verschelde, "The Costs of Data Localisation: Friendly Fire on Economic Recovery," ECIPE Occasional Paper 3/2014 (Brussels: European Center for International Political Economy, 2014).

21 Nigel Cory, *Cross-Border Data Flows: Where Are the Barriers and What Do They Cost?* (Washington, DC: Information Technology and Innovation Foundation, 2017).

22 European Commission, *The European Data Market Study: Final Report* (Brussels: European Commission, 2017).

The primary point of contention remains disparate treatment of data privacy. The United States generally takes the view that data are generated by firms in their dealings with users, and that such data may be commoditised within certain limits. In practice, this approach supports the basic business models of data providers, though not without controversy. In contrast, Europe sees data as generated and owned by the individual, implying strong means are necessary to induce firms to protect privacy of their users and acquire from them rights to exploit such information. This vision is enshrined in the EU's new General Data Protection Regulation (GDPR), which took effect in May 2018. The GDPR will elevate the rights of individuals regarding protection of privacy and personal data of EU citizens for transactions occurring within the region. It also raises new regulations regarding the transfer of data outside the EU. Finally, it harmonises regulations about data privacy and portability across member states, which should improve transparency and certainty for both firms and citizens.

Developing the GDPR is the essential cost for erecting the DSM, in light of strong European concerns about data privacy. These pillars should provide a sound foundation for solidifying and growing the data-based economy over the next decades. Still, they raise compliance costs for data firms, making their implementation controversial. It is likely that US and other international firms transacting in data will need to reconsider their European strategies and make significant investments in compliance if they wish to consider serving that market.

At this point it is impossible to know whether these new regulations will successfully build a more integrated data market and also effectively protect the privacy and security of data. On the one hand, they promise to reduce some impediments to digital trade within the EU by harmonising rules and discouraging protectionist elements of data storage and use. On the other, they raise significant costs in securing and transferring data, which may diminish investment incentives on the part of both EU-based and international enterprises. The cautionary element here is evident: to the extent that stronger rules raise the costs borne by creative small firms and entrepreneurs in accessing needed information, they may stifle such innovation.

Thus, the EU is engaged in a bold and risky change in strategy, which may both turn the terms of global competition in its favour and diminish access by smaller firms. Without doubt, other major jurisdictions, including India, Brazil, Turkey, and other key emerging economies, will watch the evolution of these markets with interest as they contemplate their own evolving standards.

5. Concluding Remarks

The ability to trade goods, services, and content digitally will only grow in importance over time as technologies improve and countries become more integrated. Digitally facilitated trade can connect more people, from more disparate locations, into mutually beneficial networks, than traditional methods of trade. Because it raises new opportunities for smaller firms and creative interests to build markets and brands around the globe, digital trade exemplifies a means for making commerce more inclusive and perhaps could serve to reduce income inequality. Moreover, digital trade has the potential to transform a number of industries in ways that we are only beginning to recognise. For these reasons, developing appropriate policy and supportive frameworks is crucial as economies move forward.

Determining appropriate policy approaches is inherently difficult in this dynamic environment, for technological change proceeds faster than legislative and regulatory solutions evolve. How the DSM is established and operates could be decisive in this context for much of the world, given the EU's economic power. However, given the relative success of the United States in promoting the digital economy and associated international trade, lessons can be taken from its experience. In essence, that history points towards sustaining a dynamic technological market and an evolving physical and intellectual infrastructure, emphasising the ability of markets to develop business models and contracting methods, and striking a reasonable balance in copyright protection, with all of this subject to light but transparent regulatory oversight. Whether that model can persevere in an environment of increasing international tensions over cyber-security and data privacy remains one of the fundamental questions of our time.

The Fourth Industrial Revolution from the European Patent Office Perspective

Yann Ménière and Ilja Rudyk

Over recent years the European Patent Office (EPO) has observed a significant rise in inventions incorporating features of software implementation rather than hardware implementation, and a rapid development of technologies such as data management and processing, wireless interconnectivity, and artificial intelligence. Most of these inventions are related to the Internet of Things and signal the considerable potential of connected and smart objects operating autonomously.

These technologies have laid the groundwork for what is frequently referred to as a “fourth industrial revolution” (4IR). While previous industrial revolutions have led to the automation of repetitive physical work, the wide deployment of autonomous objects now enables the large-scale automation of entire groups of tasks, including repetitive intellectual tasks previously performed by human beings.

Manufacturing industries are already planning the transition towards “smart” factories operating autonomously. Likewise, connected objects in transport (autonomous vehicles), energy (smart grids), cities, healthcare, and agriculture are about to profoundly change the way these sectors are organised. In a study published in 2015, the McKinsey Global Institute concludes that the different applications of the Internet of Things could generate economic value of US\$ 1.2–3.7 trillion a year in factories, US\$ 930 billion to US\$ 1.7 trillion in cities, and US\$ 170 billion to US\$ 1.6 trillion in human health and fitness.¹ In the European Union alone, the market value of the Internet of Things is expected to exceed €1 trillion in 2020.²

Patent offices are at the forefront of these transformations. They are witnessing the rise of a new breed of 4IR inventions, all computer-implemented (see Box 1) and permeating all technical fields. The rapid growth, strong software content, and pervasiveness of these inventions can pose both challenges and opportunities for patent systems as a whole. In order to be prepared, it is essential for patent offices, applicants, and policymakers to understand the scope, drivers, and implications of this technology trend.

To contribute to this understanding, the EPO has published a comprehensive study on 4IR innovation.³ Drawing on the latest available patent information, a total of 48,069 patent applications filed at the EPO with a focus on autonomous, connected objects have been identified. The analysis reveals that the number of 4IR inventions is constantly increasing, growing seven times faster than the growth of all patent applications at the EPO over the three years to 2017. It also reveals that the 4IR is the cumulative effect of several expanding information and communications technology (ICT) innovation fields which interact with each other and spill into other, traditionally non-ICT fields.

This chapter highlights the main lessons that can be learnt from this study. It provides a thorough definition of the 4IR as a combination of different technologies that enable the full exploitation of the potential of connected objects. It also explains how the inventions corresponding to these technologies have been mapped to patent data. The remaining parts of the chapter—focusing respectively on trends in 4IR innovation, applicants, and the geography of 4IR inventions—discuss the main findings that can be derived from these data.

1 McKinsey Global Institute, *The Internet of Things: Mapping the Value beyond the Hype* (New York: McKinsey Global Institute, 2015).

2 Stefania Aguzzi, David Bradshaw, Martin Canning, Mike Cansfield, Philip Carter, Gabriella Cattaneo, et al., *Definition of a Research and Innovation Policy Leveraging Cloud Computing and IoT Combination* (Brussels: European Commission, 2015).

3 European Patent Office, *Patents and the Fourth Industrial Revolution: The Inventions Behind Digital Transformation* (Munich: European Patent Office, 2017).

Box 1. Computer-implemented inventions at the European Patent Office (EPO)

In Europe, Article 52 of the European Patent Convention (EPC) excludes computer programs "as such" from patent protection. This exclusion does not mean that all inventions involving software are excluded from patenting; what it does mean is that tighter scrutiny of the technical character of these inventions is required.

The patentability of computer-implemented inventions

Over the years, the case law of the EPO boards of appeal has clarified the implications of Article 52 EPC, establishing a stable and predictable framework for the patentability of computer-implemented inventions.

Like all other inventions, in order to be patentable, computer-implemented inventions (CIIs) must meet the fundamental legal requirements of novelty, inventive step, and industrial application. In addition, it must be established that they have a technical character that distinguishes them from computer programs "as such." In other words, they must solve a technical problem in a novel and non-obvious manner.

The normal physical effects of the execution of a program, such as electrical currents, are not in themselves sufficient to lend a computer program technical character, and a further technical effect is needed. The further technical effect may result, for example, from the control of an industrial process or the working of a piece of machinery, or from the internal functioning of the computer itself (e.g. memory organisation, program execution control) under the influence of the computer program.

The EPC thus enables the EPO to grant patents for inventions in many fields of technology in which computer programs make a technical contribution. Besides representing the bulk of patent applications in information and communications technology (ICT) at the EPO, the share of CIIs in all patent applications has been rising over recent decades and is estimated to reach the 50 percent mark in such fields as automotive and medical technologies.

CIIs and 4IR

The EPO has a consistent, harmonised, and predictable approach to CIIs across all products and towards all applicants that provides an appropriate framework for delivering quality patents for 4IR inventions. Facing a growing number of CIIs in a wide variety of technical fields, the EPO has invested in its capacity to address the volume and the multidisciplinary nature of 4IR inventions.

First, staff with relevant expertise are involved in all the EPO's fields of operation to ensure the consistent application of the CII content of the Guidelines for Examination in traditional fields. For this purpose, examining divisions are composed of three members with different technical backgrounds, including CII experts when appropriate. At the same time, the EPO continues to adapt its practice to the latest technology developments, such as the recent rise of artificial intelligence. These are addressed through annual updates of the Guidelines for Examination, which are communicated throughout the entire EPO operational area thanks to regular peer-to-peer knowledge transfer events, e-learning modules for CII, and academy course materials.

On 1 January 2018, the EPO implemented a significant reorganisation. The Office's ICT area now comprises a sector of around 2,000 staff members. Besides ICT, two additional sectors have been created: Mobility and Mechatronics; and Healthcare, Biotechnology and Chemistry. Like ICT, these other two sectors comprise examiners experienced in CIIs to ensure harmonised practice in CII-related technology across all sectors.

The EPO is well prepared for these developments, through its well-established policy on the patentability of computer-implemented inventions (CIIs). In recent years, the EPO has not only closely monitored 4IR technology trends, but also invested in the internal capacity to address the growing volumes and multidisciplinary nature of 4IR inventions.

1. The Nature of 4IR

By 2020 it is estimated that 26–30 billion devices in the home and workplace will be equipped with sensors, processors, and embedded software, all connected to the Internet of Things. The fifth generation (5G) of mobile networks will support their deployment, with faster transmission rates but also lower energy consumption and reduced network latency. The truly revolutionary nature of 4IR,

though, lies in the combined use of these objects in a wide range of new technologies, such as cloud computing and artificial intelligence, which allow interconnected objects to operate autonomously.

The variety and ubiquity of the sensors embedded in connected objects make it possible to collect data of virtually any type and origin and to aggregate them into “big data,” the raw material of 4IR. Additional technologies play a critical role in supporting the exploitation of this data. Cloud computing enables efficient storage, processing, and management of these huge amounts of data in networks. Artificial intelligence can process vast amounts of data, and detect and interpret patterns that were previously impossible to identify, or even imagine, thereby enabling machine prediction, diagnostics, modelling, and risk analysis. Three-dimensional (3D) systems make the results of complex models humanly viewable. Together with new interfaces for displaying such information, they enable applications based on virtual reality in a wide range of situations, from gaming to additive manufacturing.

This combination of technologies further increases the importance of software—and thus of computer-implemented inventions—in almost all areas of technology. This feature is already familiar in computers and mobile devices, which consumers can update, upgrade, or equip with new applications without having to buy a new device. With the generalisation of the Internet of Things, the same pattern is set to apply to all sorts of hardware. A digital user interface for any connected device can be put into a tablet or smartphone application, enabling remote operation and eliminating the need for direct physical controls.

As a result, the focus of value creation and innovation is moving from traditional engineering towards the automated regulation of any type of system through the collection and analysis of data. Potential applications range from the remote monitoring of treatments for patients to the automated organisation of factories, logistics chains, and fleets of vehicles, and they are expected to have a major economic impact.

2. Landscaping 4IR Technologies

Drawing on its technical expertise and up-to-date patent information, the EPO has developed a “cartography” of the inventions underpinning these transformations. It focuses on all patent applications filed at the EPO that combine features of computing, data exchange, and autonomous decisions made by connected objects. The 4IR cartography consists of three main sectors, each of which is subdivided into several technology fields:

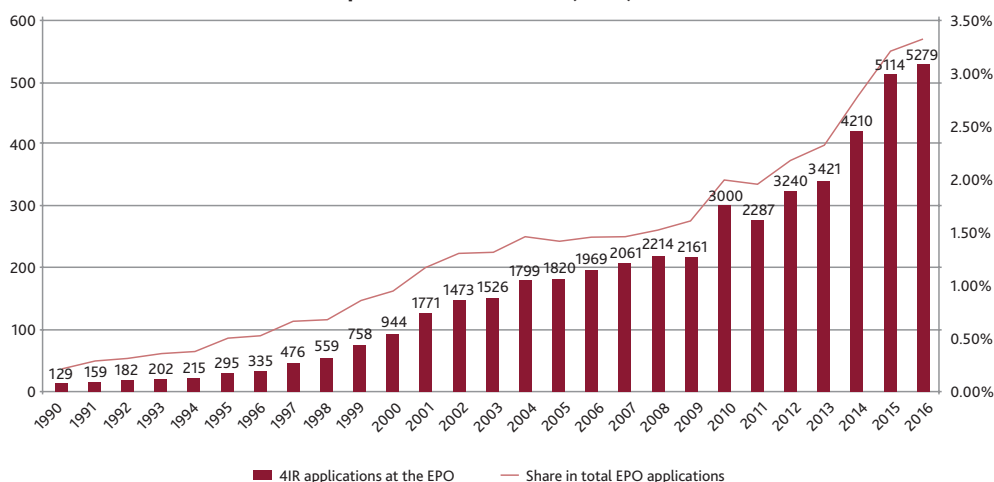
- The core technologies sector corresponds to the basic building blocks upon which 4IR technologies are built. It captures all 4IR inventions that directly contribute to the three established ICT fields: hardware, software, and connectivity.
- The second sector captures enabling technologies that complement the core technologies. It is subdivided into seven technology fields: analytics, user interfaces, 3D support systems, artificial intelligence, position determination, power supply, and security.
- The third sector, application domains, encompasses the final applications of 4IR technologies. It has been divided into six different domains: personal, home, vehicles, enterprise, manufacturing, and infrastructure.

A total of 48,069 published and unpublished patent applications filed at the EPO before 2017 were identified as belonging to 4IR technologies and sorted into the respective fields. If an invention combined features of different 4IR fields, it was automatically assigned to all of them. The analysis showed that application domains, with 70.6 percent, capture the largest proportion of 4IR inventions, followed by 4IR inventions related to core technologies, with 51.7 percent. A smaller proportion of inventions (34.5 percent) are related to enabling technologies. The share of 4IR patent applications describing technical features of three or more 4IR fields grew from 20 percent in 1990 to 44 percent in 2016, revealing increasing cross-fertilisation.

3. Trends in 4IR Innovation

The number of patent applications for smart objects began to rise steeply in the mid-1990s (Figure 1). The growth of 4IR applications has been particularly impressive, increasing by 54 percent in the three years to 2017 alone. Conversely, the total number of applications at the EPO grew by 7.65 percent in the same period.

Figure 1. Fourth industrial revolution (4IR) patent applications at the European Patent Office (EPO), 1990–2016



Source: European Patent Office.

As a result, the share of 4IR inventions in all patent applications at the EPO has been growing sharply. In the period between 2009 and 2016, it more than doubled from 1.6 percent to over 3.3 percent. With more than 5,000 patent applications in 2015 and 2016, it is already on a par with biotechnology. Core technology fields and application domains have so far attracted the largest number of patent applications at the EPO. Although enabling technology fields are characterised by lower numbers of patent applications, some of them have experienced very fast growth in recent years. Average growth rates are particularly high for 3D systems (56 percent), artificial intelligence (43 percent), and user interfaces (43 percent). In the light of ongoing developments, this rapid growth is expected to continue in future years.

4. Top 4IR Applicants

The 25 biggest 4IR applicants at the EPO in the 2011–2016 period alone account for 48 percent of 4IR patent applications. Two observations are particularly striking when looking at Table 1. First, the list is dominated by large, traditionally ICT-focused companies. Eight of the top ten and all top five applicants have their main business operations in ICT industry sectors. Second, all of the top applicants are located in Europe, the Republic of Korea, China, Japan, and the United States. BlackBerry, a Canadian company, is the only exception.

Table 1. Top 25 fourth industrial revolution (4IR) applicants at the European Patent Office (EPO), 2011–2016

Rank	Company name	Number of applications	Region	Industry (NACE)
1	Samsung Group	1634	Republic of Korea	Manufacture of computer, electronic, and optical products
2	LG Group	1125	Republic of Korea	Manufacture of computer, electronic, and optical products
3	Sony Corporation	885	Japan	Manufacture of computer, electronic, and optical products
4	Nokia Corporation	640	Europe (EPC)	Manufacture of computer, electronic, and optical products
5	Huawei Technologies Co. Ltd.	577	China	Manufacture of computer, electronic, and optical products
6	Qualcomm, Inc.	552	United States	Manufacture of computer, electronic, and optical products
7	Blackberry Limited	520	Canada	Manufacture of computer, electronic, and optical products
8	Koninklijke Philips N.V.	433	Europe (EPC)	Manufacture of electrical equipment
9	Intel Corporation	428	United States	Manufacture of computer, electronic, and optical products
10	Panasonic Corporation	413	Japan	Manufacture of electrical equipment
11	Honeywell, Inc.	375	United States	Manufacture of motor vehicles, trailers, and semi-trailers
12	Zte Corporation	314	China	Manufacture of computer, electronic, and optical products
13	Fujitsu Limited	274	Japan	Manufacture of computer, electronic, and optical products
14	Technicolor SA	268	Europe (EPC)	Manufacture of computer, electronic, and optical products
15	General Electric Company	267	United States	Manufacture of machinery and equipment n.e.c.
16	LM Ericsson AB	262	Europe (EPC)	Manufacture of computer, electronic, and optical products
17	Boeing Company	260	United States	Manufacture of other transport equipment
18	Siemens AG	256	Europe (EPC)	Manufacture of machinery and equipment n.e.c.

Table 1: *Continued*

Rank	Company name	Number of applications	Region	Industry (NACE)
19	Google, Inc.	253	United States	Manufacture of computer, electronic, and optical products
20	NEC Corporation	245	Japan	Manufacture of computer, electronic, and optical products
21	Xiaomi Inc.	230	China	Manufacture of computer, electronic, and optical products
22	Apple Inc.	224	United States	Manufacture of computer, electronic, and optical products
23	Ricoh Company Ltd	210	Japan	Manufacture of machinery and equipment n.e.c.
24	Hitachi Ltd	208	Japan	Manufacture of electrical equipment
25	Toyota Motor Corporation	193	Japan	Manufacture of motor vehicles, trailers, and semi-trailers

Source: European Patent Office.

Samsung and LG from the Republic of Korea are the companies with the highest number of 4IR patent applications. These two companies alone represent more than 90 percent of all Korean 4IR applications at the EPO. The Chinese applicants Huawei, ZTE, and Xiaomi rank 5th, 12th, and 21st on the list. Together, Huawei and ZTE account for more than two-thirds of all Chinese 4IR inventions.

Japan is represented by seven companies on the list of top applicants. Apart from car manufacturer Toyota, ranked 25th, they are conglomerates with long-established activities in ICT. Inventive activity in Japan is less concentrated than in the Republic of Korea or China. The two leading applicants together were responsible for only 30 percent of Japanese 4IR patent applications.

The United States provides 7 and Europe 5 of the top 25 applicants, including ICT champions such as Qualcomm, Intel, and Google in the United States, and Nokia, Ericsson, and Technicolor in Europe, but also several companies that are not traditionally ICT focused, such as Philips, Boeing, Siemens, General Electric, and Honeywell. The latter have their main activities in medical technologies, machinery, consumer electronics, transport, and electrical equipment.

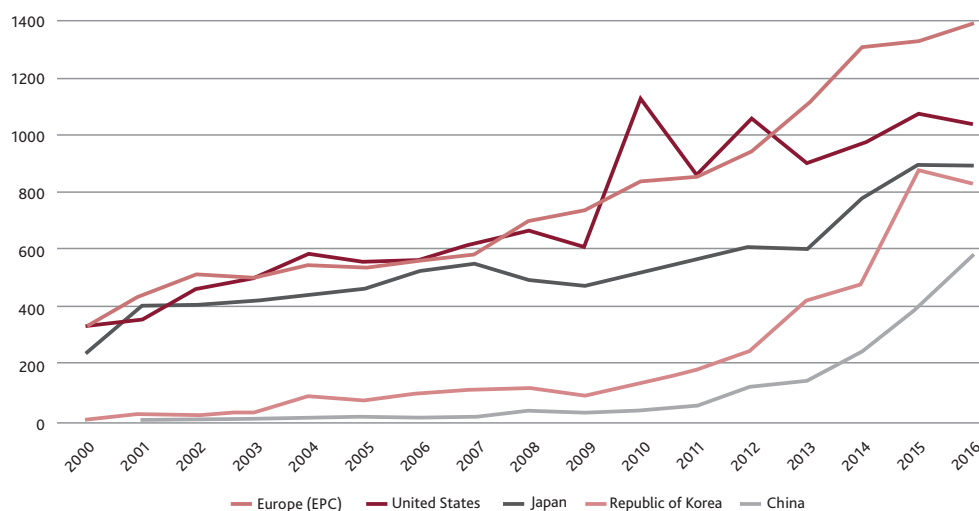
4IR inventive activity in these two regions seems to be even less concentrated than in Japan, with just 16.6 percent (United States) and 15.5 percent (EPC) of 4IR inventions generated by the respective top two domestic applicants. At the same time, European and United States applicants are much better represented outside the top 25: an additional 44 European and 37 United States companies appear on the list of the top 150 applicants, compared with only one additional company from the Republic of Korea and none from China.

5. Geographical Origins of 4IR Innovation

A focus on the geographical origins of 4IR inventions thus better reflects the actual contribution of Europe and the United States to 4IR innovation (Figure 2). Two distinct periods can be considered. Before 2011, 4IR inventive activity was clearly dominated by Europe, the United States, and Japan. More than 88 percent of all inventions originated from inventors based in these three regions.

Since 2011, the shares of the United States and Japan have decreased to 25 percent and 18 percent, respectively. Europe has maintained its share of 29 percent of all 4IR patent applications filed at the EPO, and has become the leading region. The most striking change in the years leading up to 2016, however, is the growth in 4IR inventions from the Republic of Korea and China. Their contributions jumped to 13 percent and 6 percent, respectively, of all 4IR inventions in the most recent period.

Figure 2. Origins of fourth industrial revolution (4IR) inventions at the European Patent Office (EPO), 2000–2016



Source: European Patent Office.

The Republic of Korea slowly started innovating in 4IR technologies in around 2000. China took another five years to produce a significant number of inventions. Patent applications from China and the Republic of Korea at the EPO have risen markedly since then, especially since 2010. Thanks to Samsung and LG, the Republic of Korea caught up with Japan in 2015, and may well replace it soon as the third largest innovation centre. China is not far behind.

In Europe, Germany and France are the most important innovation centres for 4IR technologies with, respectively, 8 percent and 6 percent of 4IR patent applications at the EPO between 2011 and 2016, followed by the United Kingdom and some smaller European countries, such as the Benelux countries, the Nordic countries, and Switzerland. They all differ in their 4IR technology profiles. Germany, for example, is particularly strong in the vehicles, infrastructure, and manufacture application domains. France is more focused on enabling technologies such as artificial intelligence, security, user interfaces, and 3D systems. The United Kingdom is relatively strong in power supply and position determination, but also in artificial intelligence.

6. Conclusion

This first ever landscaping of 4IR technologies illustrates the value of patent information and the leading role of the EPO as a supplier of this information. Indeed, the precise identification of 4IR fields would not have been possible without the technical knowledge of EPO examiners and the

accuracy of the Cooperative Patent Classification scheme. While a consensus on 4IR technologies is still forming, this chapter highlights the fundamental trends in this sector and provides a sound basis on which to conduct further analyses of the development of 4IR.

Our findings confirm the high potential of 4IR in many industries, and reveal its rapid development in recent years. The European economy is largely contributing to this trend, and is well positioned to benefit from it in a wide variety of industry sectors. The EPO's well-established examination practice on the patentability of CIs provides the necessary legal framework for these developments. Furthermore, the EPO has taken measures to manage a growing volume of 4IR patent applications, so it can continue to provide legally robust patent rights of the highest quality to applicants and innovators around the world.

The Promises and Perils of Digital Business Models

Sean M. O'Connor

1. Overview: Understanding the Spectrum

The modern digital economy has existed along a spectrum of different distribution models since its roots in the unbundling of software from hardware in the mid-twentieth century. This has not always been apparent to consumers or policymakers. For too long the default model was taken to be simply a digital version of sales of goods. But recently, high-profile incidents involving online music distribution platforms (e.g. Apple's iTunes), software unbundling and repackaging resellers, and digital content resale platforms have brought a greater awareness that most digital content and software (including applications, or apps) is not sold but rather is conveyed on very different terms. The problem is that the digital artefact is not sold, and thus the consumer does not receive the set of rights normally attributed to a sale of goods. Further, most consumers do not even know what rights they *do* receive. It generally does not help the consumer, or even the policymaker, to turn to the terms of service that are usually absent-mindedly clicked through or otherwise arguably assented to. The language is often dense legalese that requires lawyers skilled in these kinds of contracts to decipher.

This chapter provides an introduction to the spectrum of digital business models for consumers and policymakers. While these models exist along a true spectrum—meaning an infinitely variable range of possibilities limited only by the creativity of vendors and their attorneys—most of them cluster around three basic concepts. The first is the traditional sale of goods model, which is in fact the least common in the digital world. But because it is the starting point for most traditional consumers (millennials and other digital natives possibly excepted) and one of two poles defining the range of ownership and use rights in acquired goods, it makes sense to start there. The second is the licence model, formerly the lease-licence model when digital artefacts were conveyed to users on physical media. This was dominant for much of the history of distribution of digital artefacts, but it is rapidly being displaced by models clustered around the opposite pole from sale. Thus, the third model constituting this pole is delivery of digital artefacts as services. For each of these, I will explain the basic concept and then review its pros and cons.

The chapter then advocates a flexible regulatory environment for innovative business models, rejecting a one-size-fits-all imposition of first sale or exhaustion, albeit with heightened scrutiny of consumer contracts. Valuable innovation has occurred in new business and legal models throughout the modern knowledge economy, including the digital segment. This has benefited consumers and proprietors. In this sense, it is not only technological innovations that provide value, but also creative product and service delivery models. Accordingly, the same regulatory flexibility that legal regimes governing tech hubs like Silicon Valley and Seattle give to new technologies themselves should also apply to innovative business and legal models. For the digital economy, the threat of overly reactive imposition of tight regulation, including through end-oriented judicial decision-making, presents as many problems as the threats to consumers from “hidden” fine-print clickwrap and browsewrap licence terms, as well as those to workers in the “gig economy” supercharged by disintermediation platforms such as Uber. But because the latter cover issues that go beyond the scope of digital artefact distribution business models, this chapter remains focused on regulation of the actual distribution models.

2. Comparison of the Three Representative Models

2.1 Sales

Sale of a physical good, for example buying groceries at the market, seems like the most obvious and simple transaction to most of us. We pay money, take possession of the items, and leave the market with them knowing we can dispose of them pretty much as we like. We know that more expensive things, especially non-perishable and non-consumable things such as computers, automobiles, and boats (capital assets), generally involve a formal contract, or at least a receipt with some terms and conditions, not to mention transfer of title. Technically, title passes even for perishables and consumables, but it is often of no practical import for vendor or purchaser.

In the early days of analogue and digital electronic computing, around the 1940s and 1950s, machines were often sold in the same way as any other capital asset good. But as the market expanded to business purchasers who had little in-house capacity to program and use these machines, vendors began offering a variety of acquisition options. First, sale of the machine with an accompanying service contract. Second, lease of the machine with an accompanying service contract. And third, the machine and programming/operation delivered as a single computer processing service. These three models from the earliest days of the information technology industry then set the stage for the three representative digital artefact distribution models reviewed in this chapter.

However, the crucial distinction is that because we are considering only the digital content, operating systems, and applications here, we can never really talk about a traditional sale of goods. The digital artefact itself is not the medium that might store or run it. It is instead an intangible like other forms of intellectual property (IP), data, stock, or bonds. This became the core issue when computer vendors began unbundling software to sell or deliver separately from hardware. As some customers began developing in-house programming and operation talent, they did not need the vendors' services and sought instead to pay only for the machines—the hardware. Other customers were finding that there were independent contractors willing and able to program or run machines for less than the cost of the service component from the computer vendor, and perhaps with a wider range of customisation. Further, some programmers were launching firms to offer commercial alternatives to the computer vendors' software, which could be even cheaper for business customers.

Another distinction that emerged early on was between an operating system and an application. The former was the core software that enabled the computer to run in its most basic mode as a general computing machine, which could then be programmed for specific applications. It long remained the province of the hardware manufacturers—for the most part continuing until the young Microsoft secured its famous contract with the United States military to provide an unbundled disk operating system (DOS), and then began making a version commercially available just as the personal computer revolution of the 1980s occurred.¹ The next big change occurred with graphical user interfaces (GUIs), the kind of desktop environment we are familiar with now. It displaced the minimalist flashing cursor on a black screen, which required the user to know and type in commands

¹ Apple of course had its own operating system for its new Macintosh personal computer (Mac), but this was part of a closed system going back to the bundled origins of commercial computing products. The personal computer was first called the "micro-computer" because it was smaller than both (mainframe) computers and mini-computers that were oriented to commercial business, and not the home or amateur market. Hence, Microsoft's name: Micro(computer) + Soft(ware). In fact, early logos and use of the name emphasised the two parts by styling it MicroSoft.

just to get the computer to run any programs or applications. Apple's operating system set the baseline and many visual elements and layout, but again it was bundled with Apple's hardware and so outside of our concerns with the development of purely digital artefacts. Thus, it was again Microsoft that became the most popularly known vendor for unbundled GUI operating systems, with its transformative Windows product in 1985. Later Linux and others would supply open source and often non-proprietary operating systems, setting up the fundamental ideological rift in the programmer and user community between proprietary and closed software and applications on the one hand, and non-proprietary and/or open systems on the other.² Concomitant with the personal computer revolution was the demand for off-the-shelf applications for things such as word-processing, as the price point and obvious benefits of the personal computer were drawing in amateur users who had no capacity—or time—to program their own computers from the DOS command line alone. This is why the Mac was so revolutionary: it provided a usable machine to the amateur straight out of the box, with preloaded useful and entertaining applications on top of the core operating system.

Soon, home or amateur machines were coming preloaded with at least a GUI operating system, and possibly one or two apps. But a market continued growing for a rapidly expanding universe of apps offered by all manner of large and small firms. Further, with Microsoft not producing hardware, its DOS and Windows operating systems still had to be sold or licensed either to hardware manufacturers or dealers, who would then preload machines for sale to consumers, or directly to consumers who were up to the challenge of loading, or increasingly upgrading, their own operating systems. All of this meant a widespread distribution of unbundled software.

Stepping back to the emergence of unbundled software, however, a fundamental question for vendors and their attorneys was how to provide the intangible software as a legal matter. As a technical matter, it could be delivered either by having a programmer directly program a machine with proprietary software, or by sending physical memory media, such as tape reels in the earliest days, and then later floppy disks, that could then be used to upload the code to the machine in a few relatively easy steps. In the former, there was no transfer of a physical object. In the latter there was, but it was not the code itself; rather, it was a medium that could be encoded or recorded in such a way that the central processing unit (CPU) of the computer could read and process the encoded information to encode a new version or copy of it on to the machine's permanent internal hard drive (which is why floppy or removable disks were distinguished from both the hard drive and the code itself). Attorneys at the proprietary vendors worried that sale of the intangible copy could be argued to be sale of the code itself, meaning that the first sale of a copy would divest the proprietor of rights to the original or master code. This may seem far-fetched until one recalls that in the United States, computer code was not expressly included in the Copyright Act until 1980, and its patentability was being debated along a series of court cases that in many important ways are still not fully resolved today.

While the matter seems as if it should simply have followed the established system for distributing copies of other intangibles such as music recordings, there were two other issues. First, computing

2 An important further distinction on the "open" side is as between proprietary and non-proprietary suppliers, sometimes analogised as the "free beer/free speech" distinction. Importantly, these are not mutually exclusive. To fit in the "open" camp, one need only commit to make the software source code (human-readable version in programming languages such as BASIC, HTML, Java, etc.) available for the programming community to see, learn from, and even adapt into their own derivative programs. But the program itself can still be sold or licensed for payment, rather than given away for free.

had long been a digital system and not an analogue one. This meant that the systems for reading and encoding a new copy were the flawless reproduction of binary 1s and 0s (which allows for more noise or error in the electrical signal or encoding so long as the voltage of the "1" state is far enough from that of the "0" state), and not the degrading quality of successive copies of analogue (where even minor errors in voltage signal when reading or copying can lead to a notable change in quality and fidelity). Thus, emerged the central threat of digital media for software and content proprietors: once a digital version is released, endless perfect copies can be generated from it. Second, the software had to be copied repeatedly just to upload it to a person's machine and then, each time it was used, further uploaded to the active memory of the computer for processing by the CPU. By contrast, in the intended playback-only use of recorded music, playback devices, including vinyl record players, open-reel or reel-to-reel tape decks, eight-track cassette decks, and compact cassette decks, were only reading and not copying the source information. And again, with software not clearly covered by copyright—and with the further confusion of source code versus object or machine code³—there was no simple solution to distributing copies with a copyright notice saying "all rights reserved" and thus no copying was authorised. This was then the impetus for the use of licences, over time styled as end-user licence agreements (EULAs), as we know them today.

Accordingly, no proprietary software (operating systems or apps) was distributed through a straight sales model. Only non-proprietary code and content was distributed in this manner. Even as the copyright status of software was clarified in the 1980s, the need for specific terms as to what copying was permissible just to use the code as intended meant that a straight sale of a copy of code would not work.⁴ Further, even a simple sale of the media on which the software was encoded could create problems for the proprietor as the first sale or exhaustion doctrine would allow the recipient to reconvey it in any manner to any other person. This was not a major problem in and of itself, but it then meant that a downstream recipient would receive full title to the physical copy without also being bound by the licence that had accompanied transfer to the original end user. The downstream recipient could still not copy the code—even for the intended use of such code—but could arguably run a decompiler generating a reasonable facsimile of the original's source code. This could in turn then be distributed widely or publicly, destroying its secrecy, which many proprietor vendors relied on to keep their position and edge in the market. While it may seem improper for a software vendor to seek to keep secret important technical workings of a commercially and publicly available product, this is exactly what we allow manufacturers and distributors of physical goods to do. Thus, to the extent we think this is bad policy, then the remedy would need to apply across the spectrum of sold products.

By contrast, digital music recordings were distributed through sale of the physical media: first digital audio tape and then CDs. Early laser disk videos were also distributed through sale, but the market was small for these until the much later DVD revolution. Videocassette recorders were analogue

3 Source code has already been described. Machine or object code is the sequence of 1s and 0s that the CPU can process directly without a compiler (further software to instruct a CPU, in machine code, to transform source code into the 1s and 0s of machine code). Decompilers, unsurprisingly, can transform 1s and 0s of object code into source code.

4 Seminal cases like *MAI Systems Corp. v. Peak Computer, Inc.*, 991 F.2d 511 (9th Cir. 1993) further muddled the waters as to what copies could lawfully be made by a computer system in loading up or operating even properly acquired software. While a user with licence or title to software could have their system make the copies necessary to operate the code under express statutory authority, 17 U.S.C. § 117, such same necessary copies done by operation of the machine by, say, a computer technician hired by the user for repair purposes has been deemed infringing under the statute in some jurisdictions.

systems and so the sale of copies provided much of its own practical technical limitation on expansive unauthorised copying as did the sale of vinyl and analogue taped music recordings. But digital music recordings could still be used as intended in solely a media reading mode; no copy needed to be made of the encoded information to play it back. Thus, the simple "all rights reserved" copyright notice could still be employed effectively, at least as a legal matter.⁵

2.1.1 Pros

Given the background provided so far, which will be relevant for all of the sections in this chapter, where proprietors are willing to sell copies of intangibles such as software and content, the following benefits may apply. First, when the consumer receives physical media with no express or clearly implied IP terms, they have both the physical object (e.g. disk) and its encoded software or content as long as the physical object lasts. The user can use it in any way they see fit, other than things expressly prohibited by copyright, such as copying or publicly displaying or performing. This works well enough for readable content, but not for code that needs to be copied to the machine to be run. However, provided that the circumstances would support an implied licence or statutory authority to the purchaser to run the program as part of its normal and intended use, then the user should be able to use it in a way analogous to content media.

Second, a one-time upfront payment is all that is required for the transaction. No ongoing obligation by either party is entailed or implied by the transaction itself. Each party has the benefit of its bargain and moves forward independently.

Third, the consumer can transfer, resell, or otherwise dispose of the physical media copy. In doing so, the consumer cannot keep a copy for their continued use. This follows most cleanly in the read-only content situations, as no copies have been authorised, and the first sale doctrine does not authorise one either. But things are a bit muddier for the implied limited use licence for sold copies of software. While the licence would probably run with conveyance of the media to a third party, a vendor would have to worry that implied terms included copying to retain on a machine after conveyance to the third party, even if only for archiving purposes. It is unlikely that a court would find a continued use licence for the original purchaser in this context, but once the archival copy was made, if that original purchaser sold the machine itself, then the sale should not run afoul of copyright (due to first sale again) and the downstream purchaser arguably can use the program.

2.1.2 Cons

While pros for both proprietors and purchasers in each of our representative models can be treated together as a practical matter, their respective interests diverge too much on the con side. Accordingly, sections will be broken out for each.

⁵ Even at that time record labels were so concerned about the practical risks of the first-to-market digital audio tape that they successfully lobbied for the Audio Home Recording Act of 1992 (AHRA), P.L. 102-563, 106 Stat. 4237, which required manufacturers of digital audio tape machines to include a Serial Content Management System and pay royalties to music copyright owners. Some argue that these requirements made digital audio tape commercially infeasible, which is why the market for them failed.

Consumers

First, when physical media fail, are lost, or are stolen, the purchaser has no rights to a replacement. Neither does this eventuality give the purchaser the right to have made and now use a copy.⁶ This was obvious to most consumers in the past, but the prevalence of new models such as media lockers, in which consumers can purchase a copy of music or a movie that is then available across multiple machines they own, or on-demand streaming services, has likely changed the reasonable expectations of many consumers. Thus, even as major content providers are rushing towards digital cloud and locker models themselves, younger consumers who grew up with the new models may be shocked and unhappy that they have no rights to access music or movies purchased through conventional media such as CDs or DVDs.⁷

Second, the pricing of the copy will reflect the full life-of-object conveyance. That is, the consumer cannot find an offer to pay for only the use they will make of the physical media—it is all or nothing. In the absence of credible alternatives, like the new licensing and streaming models, then the public may be forced to pay these full life-of-media prices—that is, if they want copies of music and movies at all. It also, of course, then means that consumers can afford to buy fewer titles, presuming they have a limited budget for such purchases.

Third, proprietary software was rarely distributed this way and so, for that corner of the digital artefact market, titles were not available at any price in the sales model. To put this another way, the proprietary software industry would not have developed with its robust offerings to end users but for the existence of the other models. It remains an open counterfactual as to whether the industry would have developed differently had only sales models been allowed, including whether non-proprietary vendors would have adequately supplied the market, or whether proprietary vendors would have simply taken the chance that they could control unauthorised further distribution and copying of their products even after a first sale of the physical media encoding them.

Fourth, a simple sales model subjects the consumer to platform changes and obsolescence. Just as my eight-track cassette of Steely Dan would obviously not play or even fit in my then cutting-edge CD player of the early 1980s, digital media are not guaranteed to be forward compatible. While some vendors strive for a degree of backwards compatibility, this generally lasts for only a few versions. After that, if you have not paid for the upgrades and converted or updated your software or content, then the original versions may simply not work anymore in newer operating systems, apps, or platforms. And under the simple sale model, there is no obligation on the vendor to provide even a new version or two worth of compatibility. Thus, even if your physical media survive, or you retain authorised copies on your hard drive, there is no guarantee they will continue to be operable as you buy new machines or upgrade the operating system on your existing machine (and failing to upgrade the latter causes a host of other problems once you skip a couple of versions).

6 Other than any contractual or statutory permissions for having created an archival copy. However, this archival copy must have been made by or for the user from their own copy. In other words, I cannot make a copy from a friend's archive copy of her own copy of the same code.

7 That said, some content providers have been trying to incentivise the migration to their approved lockers and other cloud services by offering free copies of such media as a free or minimal-cost add-on to the purchase of conventional physical media. See, for example, Brooks Barnes, "Disney Throws Open the Gates to Its Own Digital Movie Service," *New York Times*, 26 February 2014, B2, https://www.nytimes.com/2014/02/26/business/media/disney-to-introduce-itunes-tie-in-for-digital-movie-sales.html?mcubz=3&_r=0.

But perhaps the greatest downside to the sales model for consumers is that often the transaction is not a sale at all. Rather, it is a licensed download or stream packaged to look like a sale. This was true of iTunes, before enough news stories made the public realise that the terms and conditions they clicked through to set up the platform in the first place established that they did not own any of their so-called purchases through the iTunes Store. A related problem is that, with the exception of external physical media, one cannot transfer a digital file resident on a hard drive of a computer without either making an unauthorised copy or transferring the whole machine (or at least the internal hard drive). Thus, a "sale" in this context is not really a sale—in the sense of a transfer of property title—because one of the core features of property is that it is alienable. No practical means to transfer the property (itself without being bundled into something else) effectively means no property and accordingly no real sale.

Software and content proprietors

For proprietors and vendors, the downsides of the simple sales model are also substantial. First, mirroring that of the consumer, vendor pricing must include full life-of-object conveyance—again all or nothing. But software and video games have long been developed with different layers or levels of features. Even music or movie content can easily have different levels or segments of value. For the latter, bonus features and so on are usually just lumped in with the core product as an additional enticement to purchasers. But multiple means of use, with very different value propositions for the user, for software and even video games mean that proprietors and vendors have long sought variable access and pricing regimes to tailor the purchase to the user (which of course benefits the user, too, as we will see). This is hard to do in the straight sale model and so presents a significant downside for software and video game firms.

Second, as outlined earlier as driving the move to other models in the first place, simple sale of physical media with no express licence component results in the release of the digital artefact "into the wild" with no limitations on decompiling and transfers (i.e. first sale applies). This was long the nightmare of content providers, many of whom approached the new digital environment—especially its online component—very cautiously. A former Microsoft executive who was present for negotiations leading to the United States Digital Millennium Copyright Act of 1998⁸ recounts that Disney executives took the position, paraphrased, that "before we put Mickey on the information superhighway, we need to know he will be protected in an armoured car." The Act thus, among many other provisions, took the anti-circumvention ideas of the Audio Home Recording Act 1992⁹ and expanded them, even adding criminal penalties. However, most of the sanctions and penalties provided applied to circumstances where content owners had already taken affirmative technical and legal measures. Thus, anti-circumvention penalties implicitly require the content owner, or its distributor, to have encoded the content into some sort of software or hardware security system. Otherwise there is nothing to circumvent. That said, even with technical and legal measures, and stiff penalties for infringement and circumvention, there has still been significant piracy: it remains too easy and profitable, especially for actors outside strong copyright jurisdictions who can nonetheless access the internet like anyone else. Accordingly, releasing any proprietary digital software or content through a simple sale model, relying on implied licences only, amplifies the potential for piracy and confusion about legal status.

8 P.L. 105-304, 112 Stat. 2860 (1998).

9 P.L. 102-563, 106 Stat. 4237.

Third, updates and patches must be shipped or pushed with no guarantee that users will apply them. This takes time and resources to ensure the delivery happens as smoothly and easily as possible for the end users. Tech support would ideally also be increased during these periods, but for firms that cannot afford much support in the first place, the odds of upgrade problems or failures increase dramatically. And if enough users have problems with the upgrades, they may abandon the software altogether, and also spread the word about it, potentially affecting sales and use more broadly.

2.2 Licences

Licensing of IP-covered goods can be traced all the way back to the Venetian Patent Act of 1474. For our purposes, the core question beginning in the mid-nineteenth century was whether the goods embodying IP as copies were licensed as well, or otherwise restricted for disposition as chattels, where the transaction with relation to the physical embodiment was characterised as a simple sale. Arising in United States Supreme Court cases like *Bloomer v. McQuewan*—which are, incidentally, far more complicated than they are generally made out to be, and which in fact have likely been misinterpreted for more than a century and a half¹⁰—the new doctrines of first sale or exhaustion (not so named for another 50 years) forced IP owners to consider leasing the physical objects, with an accompanying licence to practise the particular IP rights desired to be conveyed. Questions over whether these were true leases have followed such transactions. Without going into full detail, true leases require some termination date or meaningful reversion of title conditions, packaged into an arrangement that does not seem designed solely for evading first sale or exhaustion. In other words, there must be other real benefits to at least one of the parties that flow from the transaction being structured as a lease.

Closely related is the issue of conditional sales that seek to restrict some post-sale activities through express reservation of some IP rights. Some of the key cases in this area turn on the fact that only a notice was used—and hence there was no legally binding contract restricting any uses. Others find an enforceable contract, but use that to limit remedies of the IP owner to contract-based ones (generally monetary damages), and not IP-based ones, which can include injunctions. The United States Supreme Court decision in *Impression Products, Inc. v. Lexmark International Inc.* more or less resolved that conditional sales cannot preserve patent remedies after an otherwise authorised sale,¹¹ but the justices ran roughshod over both the complexities and the history of the cases to achieve a result that seemed simple and popular, and yet has presented more questions than it answered.

Notwithstanding these cases, nothing prevents software and content proprietors from either conveying the digital artefacts on physical media that are leased and not sold; or transferring the artefacts through the internet such that no physical media or objects change hands. The first I have dubbed the “lease-licence,” and it has been used for a long time in a surprisingly wide range of industries: everything from school band music to biological materials.¹² The second has become the

10 55 U.S. 539 (1852). For a detailed discussion of this and other exhaustion cases, see Sean M. O'Connor, “Origins of Patent Exhaustion: Jacksonian Politics, ‘Patent Farming,’ and the Basis of the Bargain,” University of Washington School of Law Research Paper No. 2017-05 (Seattle, WA: University of Washington School of Law, 2017), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2920738.

11 581 U.S. ____ (2017).

12 See, for example, Sean M. O'Connor, “IP Transactions as Facilitators of the Globalized Innovation Economy,” in Rochelle Dreyfuss, Diane L. Zimmerman, and Harry First (eds), *Working Within the Boundaries of Intellectual Property* (Oxford: Oxford University Press, 2010); and Sean M. O'Connor, “The Use of MTAs to Control Commercialization of Stem Cell Diagnostics and Therapeutics,” *Berkeley Technology Law Journal* 21 (2006): 1017.

medium of choice in large part because of speed and convenience. But it is likely then only a licence as no physical thing is being conveyed which would need to be leased.

2.2.1 Pros

There are many advantages to this model for both consumers and proprietors. First, consumers can purchase only the rights they want, and for as long as they would like them. This has generally reduced prices dramatically, although some understandably query whether prices will go up again once we have all converted over and physical media are no longer a practical or commercially feasible option. But so long as there are different option levels of features, then at least consumers still have different price points they can buy in at. And nothing prevented software or content owners from raising prices in the physical media world either. At least here, again, there will be some pricing differentials, even if the whole range seems skewed too high for the value propositions presented.

Second, the licensing—and even lease-licensing—models have generally facilitated offers of rights to use the software or content on multiple devices. This has been a major boon to those with different machines in different locations, allowing them to stay productive, or entertained, wherever they are without having always to bring one particular machine along. As part of this, some proprietors have authorised limited forms of transfer or sharing among family or even a defined friend circle. And, of course, so-called enterprise licences have been crucial for businesses and other organisations. For more than the cost of one copy, but far less than the cost of multiple copies at retail, an enterprise can buy a licence authorising x number of installations or users, all while working from just one set of physical media, as applicable. Third, as discussed, the proprietary software industry developed on a licence model. It might not have arisen, or perhaps not as robustly, without the lease-licence option in the days of physical media alone.

2.2.2 Cons

Consumers

Because there has been no sale, exhaustion or first sale do not apply and the lessee-licensee cannot resell or transfer freely either the digital artefact, nor any physical media conveying it. ReDigi's efforts to create a platform for resale of digital content failed in the courts after the company's lawyers tried to mislead the judge as to what exactly was happening with the technology.¹³ In their zeal to make it seem as analogous as possible to the conveyance of a physical thing—which could not be in two places at the same time and thus the logic of first sale would apply—they mischaracterised the technology as “lifting” a copy of the original file from one hard drive, as if it were a tangible physical layer, and then placing it down, intact, on the buyer's hard drive. This conveniently also glossed over the crucial fact that instead multiple copies of the file were being made along the way, with nothing other than the company's program resulting in erasure of the original copy on the seller's hard drive, and then a new copy being encoded into the purchaser's hard drive. The upshot is that there is no current legal path for a resale market absent express authorisation in the lease-licence, or licence alone governing the first rights acquisition. However, the case is currently on appeal at the United States Circuit Court for the Second Circuit, which may entertain a fair use angle even if the first sale one continues to fail.

13 *Capital Records, LLC v. ReDigi Inc.*, No. 12-0095 (S.D.N.Y. 2012).

Another downside for consumers in the lease-licence models is the planned or conditional termination of rights. This is the flip side, of course, of the presumably lower price of licensed, rather than sold, content. But the issue is again in the leases disguised as sales, such as the iTunes debacle. The original 99 cents per song was promoted as a purchase of the song, and in the normal course of things the buyer had an unlimited term to play it. But violating other provisions of Apple's EULA, or other conditions at Apple's discretion (such as upstream licensing problems with the labels, which of course had to authorise Apple's sale (licence) of the content in the first place), could mean that songs would unexpectedly disappear from a consumer's library, either temporarily or permanently. In a bizarre reverse implication of the iTunes' licensing system, a U2 album then dropped with no warning into every user's library, whether wanted or not. Further, the album has proven very hard to delete from each user's iTunes library. Related to this, technological protection measures such as digital rights management (DRM) can be frustrating and block even some uses that users expected.

Software and content proprietors

The same DRM that frustrates some licensees is also a cost for software and content proprietors. However, without it they could likely not monitor or enforce the limits that constitute the particular licence purchased. And without such monitoring and enforcement, proprietors might have to return to a one-price, full rights system that would make few happy. At the same time, software and content files are still released "into the wild" in the lease-licence model. While licence restrictions on decompiling and so on can impose liability for unauthorised dissemination of code, they cannot actually prevent it. Accordingly, and even with sophisticated DRM and other technological protection measures, licensed files can still be pirated. Further, updates and patches still need to be delivered via physical media or pushed out through the internet. Licensees can be required by the terms and conditions of the licence to apply them, but that is still no guarantee this will actually happen.

2.3 Services

The "newest" trend in delivery of software and content goes back to the earliest days of the computing industry, as described above. Delivering hardware and software—again generally left undistinguished in the early days—as a service made all kinds of sense for reasons still true today. However, one downside for the hardware component was that a service could not be treated as a capital asset or expense for tax and accounting purposes. This, together with the unbundling of software, may have been a factor in the limited growth of the computers-as-service model, even though it never really disappeared. For our purposes, however, it was the opening up of enough reliable bandwidth in the 1990s, along with increasing access for businesses and consumers, that enabled what was then called software as a service (SaaS). This was in many ways based on the old master-slave terminal distribution for mainframe computers. Because the early computers were so large—the early ones took up an entire room—and yet could accommodate a number of simultaneous users, it became common to link a number of "dumb" or "slave" terminals (just a monitor and keyboard, with or without a mouse in the early days) to one "master" mainframe. Thus, the operating system and all apps resided solely on the master, with the slave terminals accessing and working them remotely, as it were. SaaS is the same idea, but now the master is the software or content vendor's own servers, generally protected behind a firewall, and the slaves are

external customer or client computers that simply access and work the code behind the provider's firewall. A popular example of this is Google Docs, which was part of the suite of offerings in large part designed for the first Chrome notebooks (Chromebooks), which would be inexpensive and risk-free for the customer's software and content because none of it would reside on the notebook. All the Chromebook had to do was provide an interface to Google's servers and all processing and so on would be done behind Google's firewall. On the content side, streaming is the most prevalent example of content as a service.

2.3.1 Pros

Some of the benefits for consumers and proprietors are the same for service as they were for licences. Consumers need purchase only the rights they want. Vendors can customise offerings across the full range of market demand.

A key difference, though, is that updates and patches can be applied whenever the proprietor wants and generally without interrupting service for users. This is because the proprietor is only updating its own servers. Thus, it fully controls the timing and operation of this process. For example, it can be scheduled for a time of low user use. But even beyond this, sophisticated vendors will set up the updated programs or content on different server space from that which customers are using. This means they can fully test the new programs and content privately before they are made available to customers. Once satisfied with the operation of the new programs or content, the provider can then more or less instantaneously redirect customers from the server space containing the old programs or content to the new space, or port and run the new code to the existing servers. If all goes well, customers will have no idea that a change has occurred, until they notice that new features or content are now available.

A further benefit is that full code or content is not cluttering users' hard drive space. For anyone who has hit the upper limit on memory space, this is no minor matter. Plus, again following the Chromebook model, customers could save money on their machines because they would not need to purchase models with so much hard drive memory space—although processing speed and random active memory (RAM) would still be crucial. On the flip side, this also means that proprietors have not released their code into the wild.

Finally, consumers can generally afford exponentially more content via subscription services than by purchase of individual copies of each content object. This is one of the main attractions driving the explosion in streaming services. I can never hope to purchase the entire music catalogues of the major record labels, not to mention many of the minors or independents. But by paying an affordable monthly amount to a popular streaming service such as Spotify, I now have access to essentially all of this music.

2.3.2 Cons

Consumers

As with the pros, some of the basic downsides are shared with the licence model. There is no ownership of physical media or the digital object and so there can be no resales/transfers without proprietor permission. Further, if the user stops making monthly payments, then whatever

streaming content, SaaS, or apps were being paid for are rendered inaccessible. Further, such suspension or termination is far easier and certain given that the vendor can simply deny access to its servers where the software or content resides.

One difference, however, is that there is generally no guarantee of what content or software features will be available on an ongoing basis. Not only can the providers quickly swap things in and out as a technological matter, but the terms and conditions covering these services usually authorise this, and disclaim guarantees, warranties, and liability for any particular continuity of programs or content. The only recourse is for the consumer to stop paying and shift to another provider (if another is possible or available).

Another concern is the potential for lack of permanent records and culture. In the past, publication was a fraught step because it committed the speaker to a permanent record of their expression at that time. But in service and streaming models, expressions can be changed without a trace (unless someone took a screenshot or was otherwise able to secure some form of copy or record). While it is true that high-profile bloggers, tweeters, and other social media users may have people who are tracking their statements, as well as any changes, many more mundane people will not be so monitored. Even the United States Supreme Court has changed text in opinions available through online services.

Finally, streaming and SaaS models have very limited usability when a person's machine or device is offline. In response to criticism, and I suppose lost customers, some providers have found ways to allow users to store at least some program features or content for use offline. But the more this is enabled, the more it cuts against some of the core benefits of streaming and service, such as reduced memory requirements for consumers and the relief of not placing key properties out into the wild.

Software and content proprietors

Downsides for proprietors flow from the value proposition of the service model for users. Near 100 percent uptime rates and smooth updates, together with the newest features, are expected. Thus, proprietors have to spend the time and resources to ensure that these expectations are met. When they are not met, users can shift providers more easily since they are not invested in code and extensive installations on their machines (less so where service is a platform where a user has created significant content that is hard to port to a different provider's servers/service).

On a different front, however, stream ripping services are becoming more widespread and diminish or eliminate one of the main advantages to proprietors of streaming. In stream ripping, a user or hacker can capture and aggregate the stream of data—meant to only reside ephemerally on a user's computer and solely enough to display or perform the media (e.g. movies or music) plus a buffer for uninterrupted playback—into a single reconstituted file. Thus, the control benefits of streaming are circumvented because the ripper now has the equivalent of a downloaded file. While this likely does not affect SaaS, as the processing goes on solely behind paywalls and firewalls, it could have a disastrous impact on content streaming models. If they become just one more piracy-enabling platform, then proprietors may be forced to develop still further new ways of delivering the value proposition of their content to end users.

3. The Need for Ongoing Transaction Flexibility and Heightened Scrutiny of User Contracts

While there are calls to override licence and service transactions and transform them into sales to allow first sale to apply,¹⁴ this would not benefit consumers or proprietors overall. Many users enjoy paying only for what they want with software/apps, as well as relatively low monthly rates for access to an enormous volume of content through subscription services. Plus, the benefits of seamless updates and more free space on hard drives is good for both consumer and proprietor.

But few users, if any, read the terms of service and privacy policies for the digital things they acquire through licence or access as a service. As Perzanowski and Schultz rightly point out, the gap between the marketed rights and the actual legal rights conveyed can be dramatic.¹⁵ A partial solution is heightened judicial scrutiny of terms of service and privacy policies when issues arise—especially where legal rights are clearly different from advertised rights. Regrettably, plain English short summaries of legal rights are often just as misleading.

A better solution would be the standardisation of contract elements (but not the entire agreement) and truth-in-disclosure rules such as instituted for loan and credit card interest rates in the United States. Consumers could then easily understand what their rights were. This in turn would allow expectations to meet reality and consumers to make informed choices about where to acquire or access digital artefacts from along the spectrum of different legal and business models.

¹⁴ See, for example, Aaron Perzanowski and Jason Schultz, *The End of Ownership: Personal Property in the Digital Economy* (Cambridge, MA: MIT Press, 2016).

¹⁵ Ibid.

Expanding Patents in the Digital World: The Example of Patents in Software

Catalina Martínez

1. Software as an Asset*

Generally defined as “a set of instructions for a computer to perform certain tasks,” software is now run on all kinds of different devices in addition to computers, from mobile telephones to medical instruments, machine tools, and cars, to give a few examples. Including the word “computer” in its definition may be too restrictive. But its ubiquity is only one of its recent transformations. Research on artificial intelligence is changing the way software code is written. Software as a service and cloud computing, the Internet of Things, and open source software also have a strong impact on how firms and users in general perceive software development and use. Likewise, in economic terms, the software sector is only part of the picture in talking about the value added generated by software development. The software industry comprises firms producing software to be sold or licensed, with the value generated by in-house software development across all industries rapidly growing and becoming more difficult to trace, as well as software being created by open source software communities.

The aim of this chapter is to briefly review the past two decades of developments in software patenting in the United States and Europe. Software patenting is a complex area that has been the focus of a large number of economic and legal studies in recent years; an exhaustive account of all changes and issues is beyond the scope of this chapter, so we will offer only a summary of some highlights.¹

Three main messages emerge from our analysis. First, software-related inventions are permeating all technology areas, and patents to protect them are more frequently filed in the United States than in Europe. Second, both open source software and software patents are increasing and coexist in existing business models. Third, for software-related patents to serve their objective of fostering innovation and diffusing knowledge, patent offices should maintain a high bar on disclosure requirements and ensure that the novelty and inventive steps thresholds are strictly applied.

New ways should be found to help to ensure that the wealth of software code and algorithms that are already in the public domain, many of them protected by open source software licences, are used as prior art to prevent “trivial” patents being granted and, more importantly, eventually being used to block innovation and distort competition.

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1 For recent reviews of issues related to software and patents and patents on computer-implemented inventions, see R. Bakels, R.A. Ghosh, S. Torrisi, and G. Thomas, *Study of the Effects of Allowing Patent Claims for Computer-Implemented Inventions* (Maastricht: UNU-MERIT, 2008), http://publications.europa.eu/resource/cellar/90421535-ff72-46f3-b09e-a4bb8e0e711b.0001.01/DOC_1; A. Strowel and S. Utku, *The Trends and Current Practices in the Area of Patentability of Computer Implemented Inventions within the EU and the US* (Brussels: European Commission, 2016), <https://ec.europa.eu/digital-single-market/en/news/report-trends-and-current-practices-area-patentability-computer-implemented-inventions-within>; C. Pentheroudakis and N. Thumm, “Innovation in the European Digital Single Market: The Role of Patents,” Thematic Report on the Brussels Conference, 17 March 2015, <https://ec.europa.eu/jrc/en/publication/euro-scientific-and-technical-research-reports/innovation-european-digital-single-market-role-patents-thematic-report-brussels-conference>; and CIFRA, *Challenging the ICT Patent Framework for Responsible Innovation: A Literature Review* (Madrid: CIFRA, 2016), <http://www.cifra-h2020.eu/results/>.

2. Pervasiveness of Software

The importance of software-related inventions outside the software sector was documented as soon as the early 2000s, when a report from the Organisation for Economic Co-operation and Development (OECD) stated that less than 10 percent of software patents in the United States were granted to software companies. The same report stated that, according to survey data, between 25 and 40 percent of total business expenditure on research and development (R&D) had a software-like outcome, reflecting the fact that “many operations which used to be monitored by mechanical means are now mediated by software.”²

More recent evidence confirms the importance of software for the economy. Two studies carried out by the Economist Intelligence Unit and released in 2016 by the Business Software Alliance estimate the direct value added of the software industry for the United States in 2014 at US\$ 475 billion and the sum of its direct and induced effect at more than US\$ 1 trillion.³ The figures were equally high for Europe, with a direct value added of €249 billion and total value added of €910 billion—that is, 2 percent and 7.4 percent respectively of the gross domestic product in the European Union (EU).⁴

The stakes are high, and the relevant actors, strategies, and business models are changing rapidly. Routine manual processes are automated and artificial intelligence is used to improve knowledge about business, markets, and clients. Data become a strategic asset for the digital transformation of industries, led by internet-based firms and now crucial to all sectors (banks, pharmaceutical companies, automotive industries, aerospace, etc.). Large firms share their software frameworks and libraries. Open source software code adopted by the community enters as a building block in a modular process of software development. The question of “who owns what” gains in importance but is not easy to answer, particularly as regards “data and algorithms” and when the line between “user and producer” is difficult to draw.

3. Intellectual Property Rights and Software Business Models

National copyright laws and the EU Software Directive 2009/24 protect computer programs as literary works.⁵ According to Article 2 of the Copyright Treaty of the World Intellectual Property Organization (WIPO), copyright “extends only to expressions and not to ideas, procedures, methods of operation or mathematical concepts as such.”⁶ Thus, copyright does not protect against different expressions of innovative algorithms producing the same effects. Patents instead can protect the “structure” and “functionality” of software-related inventions. The extent to which software-related inventions can be patented varies across patent systems, and the United States has been traditionally more permissive than Europe, but it seems both jurisdictions are now reaching convergence, as we will see later.

2 Organisation for Economic Co-operation and Development, *Patents and Innovation: Trends and Policy Challenges* (Paris: Organisation for Economic Co-operation and Development, 2004), <https://www.oecd.org/sti/sci-tech/24508541.pdf>.

3 BSA/The Software Alliance, *The \$1 Trillion Economic Impact of Software* (Washington, DC: BSA, 2016), http://softwareimpact.bsa.org/pdf/Economic_Impact_of_Software_Report.pdf.

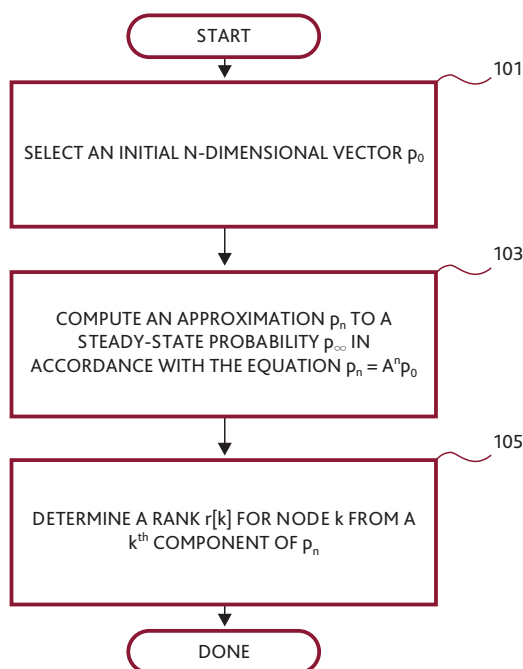
4 BSA/The Software Alliance, *Software: A €910 Billion Catalyst for the EU Economy* (Washington, DC: BSA, 2016), http://softwareimpact.bsa.org/eu/pdf/EU_Economic_Impact_of_Software_Report_en.pdf.

5 Directive 2009/24/EC of the European Parliament and of the Council of 23 April 2009 on the Legal Protection of Computer Programs.

6 WIPO Copyright Treaty (adopted 1996), <http://www.wipo.int/treaties/en/ip/wct/>.

To understand how a computer program or software algorithm can be protected by a patent, take Google's PageRank algorithm. Google's PageRank or "method for node ranking in a linked database,"⁷ invented by Google's co-founder Larry Page, is protected by a 2001 US patent filed in 1998 by Stanford University, where the founders of Google were students at the time. That first patent was not extended abroad, and would probably not have passed the patentability test at the European Patent Office, but it has been cited by more than 1,000 other patents filed in different offices worldwide.⁸ As indicated in Figure 1, the diagrams in the description of the patent illustrate the structure and different steps of the program, but the patent does not provide instructions on what specific code shall be used to implement it. In return for the exclusivity period granted by the patent, however, the applicant is obliged to disclose the invention, whereas software code protected by copyright can be kept secret.

Figure 1. PageRank patent figure



Source: Method for Node Ranking in a Linked Database, <https://patents.google.com/patent/US6285999>.

Copyright is used to protect software in both open and proprietary models. For example, the source code of Microsoft Office is kept secret, protected by copyright, and users pay a licence to use it on their computers. In contrast, Open Office source code is available for anyone to freely modify, extend, and improve, but all changes must be made available if published. Open source models rely on copyright, but licensing fees are waived in return for the commitment to share improvements with the community.⁹

7 US Patent (US 6,285,999), "Method for Node Ranking in a Linked Database," <https://patents.google.com/patent/US6285999>.

8 A quick search in patent databases shows that more than half of the patents citing the first PageRank patent have been filed by Google.

9 For more information on different open source software licensing models, see the Open Source Initiative at <https://opensource.org/licenses>.

Open source software has experienced a spectacular growth in recent years.¹⁰ It is now supported not only by a large community of individual software developers but also by an increasing number of large traditional information technology (IT) firms. At the same time, top software companies such as Microsoft, which only protected its products with copyright until the 1990s, are now among the largest patent applicants, and even the strongest supporters of open source software are patenting, defensively they claim, as they argue it is increasingly hard to compete in software-related markets without using patents as weapons to fight back.¹¹

Further economic research on the interaction between software patents and open source software would be needed. As noted in an OECD report back in 2004, when open source software had just started and its future development was still unclear, "it would be worth exploring whether patent protection could be useful to open source software developers in creating sustainable business models and markets for technology, while guaranteeing the disclosure of source code."¹² Patent pools to cross-license and guarantee freedom to operate for open source software are examples of that kind of initiative already in place.

4. Identifying Software Patents

There is no single international patent classification (IPC) class for software-related inventions, and they are not flagged as such in patent office databases. Because of their pervasiveness, but also because applicants try to get around patentability constraints by drafting software-related claims at a level of abstraction that makes difficult to identify them, it is not easy to identify software-related patents in patent databases.

Three methods have been used to track the growth of software patenting in patent offices: (1) select software-related IPC classes; (2) search for keywords in titles, abstracts, and claims; and (3) ask technical experts to review a sample of patents. The diverse focus of available studies makes their results difficult to compare, and they all offer approximations. None is free of type I errors (false negatives, failure to identify all software-related patents) and type II errors (false positives, inclusion of non-software-related patents in the selection). Nevertheless, most evidence points at the increasing importance of software-related claims in patenting.

Early studies of software-related patents relied on data on US patents. Allison and Lemley in 2000¹³ and Allison and Tiller in 2003¹⁴ identified software patents and business method patents, respectively, performing a detailed revision of a sample of patent documents and keyword searches

10 D. Thakker, M. Schireson, and D. Nguyen-Huu, "Tracking the Explosive Growth of Open Source Software," TechCrunch, 7 April 2017, <https://techcrunch.com/2017/04/07/tracking-the-explosive-growth-of-open-source-software/>.

11 The largest open source software service provider, Red Hat, Inc., justifies its patenting strategy as follows: "we have been developing a defensive patent portfolio to deter those not interested in the success of open source software from using their patents to attack Red Hat and the open source community" (www.redhat.com).

12 Organisation for Economic Co-operation and Development, *Patents and Innovation: Trends and Policy Challenges* (Paris: Organisation for Economic Co-operation and Development, 2004), <https://www.oecd.org/sti/sci-tech/24508541.pdf>.

13 J.R. Allison and M.A. Lemley, "Who's Patenting What: An Empirical Exploration of Patent Prosecution," *Vanderbilt Law Review* 53 (2000), <https://law.stanford.edu/publications/whos-patenting-what-an-empirical-exploration-of-patent-prosecution/>.

14 J.R. Allison and E.H. Tiller, "The Business Method Patent Myth," *Berkeley Technology Law Journal* 18.4 (2003), <http://scholarship.law.berkeley.edu/cgi/viewcontent.cgi?article=1432&context=btlj>.

on bigger sets. Bessen and Hunt used keyword search to identify for the first time the rapid growth in software patents at the United States Patent and Trademark Office (USPTO) between 1980 and 2000.¹⁵ Graham and Mowery identified a group of software-related patent classes based on the patenting activity of large software vendors.¹⁶ More recent US studies have studied the relation between software patents and market entry, financing of start-ups, and market valuation of software firms¹⁷ and find evidence of “a change in IT innovation that is systematic, substantial, and increasingly dependent on software.”¹⁸

As regards Europe, two empirical studies using European Patent Office (EPO) patents are worth mentioning among those attempting to identify software patents. Rentocchini relied on the Gauss wiki database to find more than 30,000 EPO software patents filed in 1978–2004.¹⁹ He observed that software patents are owned mainly by US and Japanese firms in the electronics and IT hardware sectors and tend to experience a longer examination process than other patents. Second, Frietsch and colleagues used a keyword-based method to identify German and EPO patents from 2000 to 2010 on computer-implemented inventions (excluding patents on software “as such”) and showed that since 2002 more than 35 percent of EPO filings were computer-implemented inventions (e.g. inventions related to information and communications technology (ICT) and embedded software).²⁰

5. Software Patenting Trends

The distribution of patent applications filed in the past decades at the USPTO and EPO across technology fields²¹ shows that electrical engineering, which includes computer technology and IT methods for management, has clearly been growing in relative terms in both offices over time (Figure 2). The trend is more pronounced at USPTO, where it has coincided with a decrease, in relative terms, of mechanical engineering. Patents in the field of instruments, which also include many software-related inventions, have increased their share in the total of patents granted in both offices.

15 J. Bessen and R.M. Hunt, “An Empirical Look at Software Patents,” *Journal of Economics and Management Strategy* 16.1 (2007): 157–189.

16 S.J.H. Graham and D.C. Mowery, “Software Patents: Good or Bad News?” in R.W. Hahn (ed.), *Intellectual Property Rights in Frontier Industries* (Washington, DC: American Enterprise Institute, 2005), 45–80.

17 I.M. Cockburn and M.J. MacGarvie, “Patents, Thickets and the Financing of Early-Stage Firms: Evidence from the Software Industry,” *Journal of Economics and Management Strategy* 18.3 (2009): 729–7273; I.A. Cockburn and M.J. MacGarvie, “Entry and Patenting in the Software Industry,” *Management Science* 57.5 (2011): 915–933; B.H. Hall and M. MacGarvie, “The Private Value of Software Patents,” *Research Policy* 39.7 (2010): 994–1009; and L.G. Branstetter, M. Drev, and N. Kwon, “Get with the Program: Software-Driven Innovation in Traditional Manufacturing,” NBER Working Paper No. 21752 (Cambridge, MA: National Bureau of Economic Research, 2015), <http://www.nber.org/papers/w21752>.

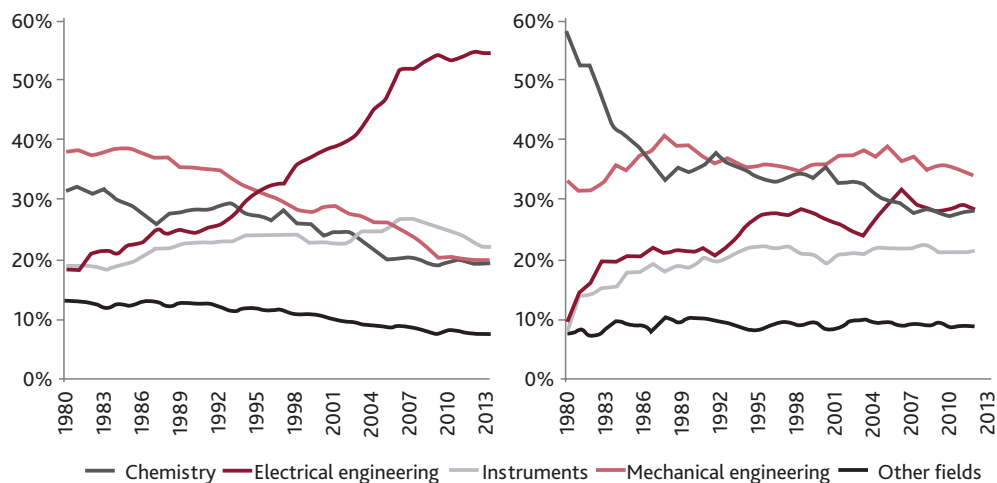
18 A. Arora, L.G. Branstetter, and M. Drev, “Going Soft: How the Rise of Software Based Innovation Led to the Decline of Japan’s IT Industry and the Resurgence of Silicon Valley,” *Review of Economics and Statistics* 95.3 (2013): 757–775.

19 F. Rentocchini, “Sources and Characteristics of Software Patents in the European Union: Some Empirical Considerations,” *Information Economics and Policy* 23.1 (2011): 141–157.

20 R. Frietsch, P. Neuhäusler, K.-J. Mellulis, O. Rothengatter, and S. Conchi, *The Economic Impacts of Computer-Implemented Inventions at the European Patent Office*, 4iP Council, June 2015, http://www.4ipcouncil.com/application/files/1314/5277/3742/Economic_impact_of_CII_at_EPO.pdf.

21 U. Schmoch, *Concept of a Technology Classification for Country Comparisons* (Geneva: World Intellectual Property Organization, 2008), http://www.wipo.int/export/sites/www/ipstats/en/statistics/patents/pdf/wipo_ipc_technology.pdf.

Figure 2. Growth in patents granted by the United States Patent and Trademark Office (USPTO) and the European Patent Office (EPO) by main World Intellectual Property Organization (WIPO) technology field, grant years 1980–2013



Source: EPO's PATSTAT database, April 2016; and WIPO technology fields from U. Schmoch, *Concept of a Technology Classification for Country Comparisons* (Geneva: World Intellectual Property Organization, 2008), http://www.wipo.int/export/sites/www/ipstats/en/statistics/patents/pdf/wipo_ipc_technology.pdf.

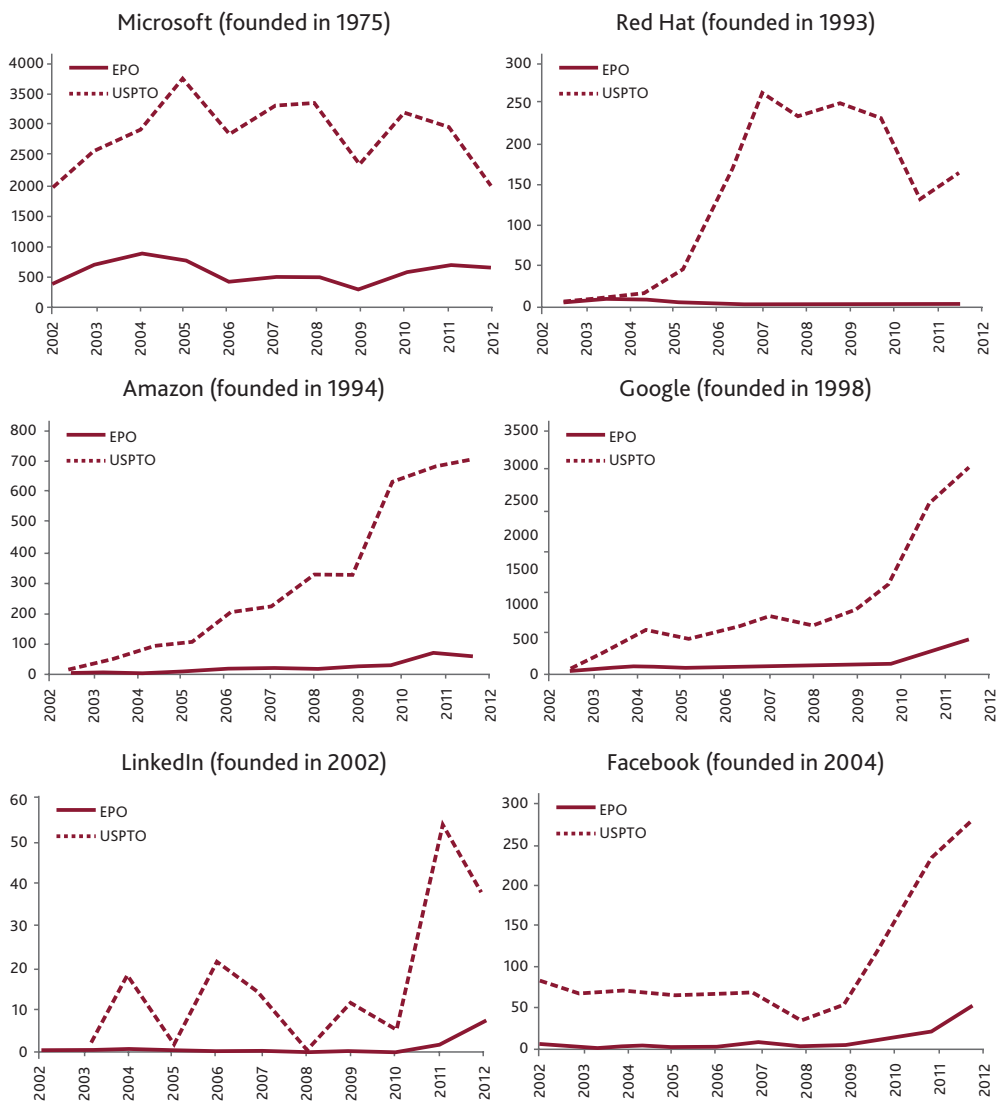
A look at patent filing trends in both offices for a selection of firms also illustrates that the growth in patenting has been primarily felt in the United States, but has been followed at the EPO (Figure 3). As mentioned earlier, Microsoft mainly relied on copyright until the 1990s, but it is now one of the largest patent applicants worldwide. Red Hat has filed hundreds of patents in the USPTO and also a few at the EPO. Likewise, Amazon, Google, LinkedIn, and Facebook, to name a few of the top internet-based giants, also patent mainly in the United States and increasingly at the EPO, and they do so with different degrees of intensity depending on their areas of activity.²²

6. The Patentability of Software-Related Inventions

The practice in the United States has been shaped over the years by case law. A crucial case was *Alice*, decided in 2014 by the United States Supreme Court. In that judgment, the court gave maximum importance to the non-obviousness and disclosure requirements, barring patents on "abstract ideas." In Europe, as governed by the European Patent Convention (EPC) of 1973, the position has always been that software "as such" is not patentable subject matter and the patentability of computer-implemented inventions is judged on the basis of the technical features of the invention (non-technical features do not contribute to the inventive step): to be patentable, an invention has to solve a technical problem with technical means. Table 1 summarises the main milestones in software patentability in both jurisdictions.

²² Not all the patents filed by this selection of firms are certain to be software-related, but given their primary sectors of activity, we expect many if not all of them to contain software claims or to be computer-implemented inventions in the broad sense of the term.

Figure 3. Patent filings at the United States Patent and Trademark Office (USPTO) and European Patent Office (EPO) by a selection of firms, 2002–2012



Source: EPO's PATSTAT database, April 2016.

The positions of the USPTO and EPO seem to be converging, but there are still critics; as recently argued by legal experts in a report commissioned by the European Commission, "both the EPO and United States methodologies for determining subject-matter eligibility involve legal uncertainty and present difficulties for practitioners, applicant and patent holders."²³ The same experts argued that

²³ Strowel and S. Utku, *The Trends and Current Practices in the Area of Patentability of Computer Implemented Inventions within the EU and the US* (Brussels: European Commission, 2016), 5, <https://ec.europa.eu/digital-single-market/en/news/report-trends-and-current-practices-area-patentability-computer-implemented-inventions-within>.

Table 1. Software patentability

United States*	Europe
1972 – US <i>Gottschalk v. Benson</i> (algorithms ineligible)	1973 – EPC Article 52(2) (schemes, rules, and methods for performing mental acts, playing games, or doing business, and programs for computers claimed “as such” are excluded from patentability)
1978 – US <i>Parker v. Flook</i> (algorithms ineligible)	
1981 – US <i>Diamond v. Diehr</i> (machine-or-transformation test)	<i>Case law of EPO Boards of Appeal</i> (technical effect beyond the normal physical interaction between the program and the computer)
1982 – CAFC created	
1994 – CAFC <i>Alappat</i>	<i>National case law (UK, France, Germany, etc.)</i> (not always consistent with EPO Boards of Appeal)
1994 – CAFC <i>Lowry</i>	
1998 – CAFC <i>State Street Bank</i> (useful, concrete, and tangible result test)	2002–2005 – <i>Proposal for EC Directive on patentability of computer-implemented inventions (rejected)</i>
2007 – US <i>KSR v. Teleflex</i> (stricter obviousness test)	2010 – Opinion EPO Enlarged Boards of Appeal: ((1) divergence is a legitimate development of case law; (2) status quo affirmed, based on inventive step and technical character of claimed subject matter)
2008 – CAFC <i>Bilski</i> (machine-or-transformation test)	
2010 – US <i>Bilski v. Kappos</i> (business method patents ineligible)	
2012 – US <i>Mayo v. Prometheus</i> (abstract idea cannot be considered new; implementation must be inventive)	
2013 – CAFC <i>Alice</i> (plurality of opinions)	
2014 – US <i>Alice</i> (two-step analysis: (1) if it claims an abstract idea is not patentable; (2) inventive implementation)	

* “US” cases are those decided by the United States Supreme Court. CAFC is the Court of Appeals for the Federal Circuit, which is the only appellate-level court with the jurisdiction to hear patent case appeals.

the heterogeneity of computer-implemented inventions “and the various levels of abstraction in which they may be attempted to be patented” has been one of the main reasons why it has been so difficult to find a single solution for patentability in this area.²⁴

7. Conclusions

It is difficult to assess how much of the growth in software-related patent applications responds to increased innovation and how much is just a consequence of higher patent propensity in the field.²⁵ Roughly one out of three patents is now software-related. Most of them are filed in the United States, but many are also filed at the EPO. Freedom to operate, or the ability to sell a product without infringing anyone's patents, remains an important challenge. However, the increasing success of the open source model²⁶ and the early years when software vendors relied

²⁴ Ibid., 11–12.

²⁵ CIFRA, in its Horizon 2020 project, notes that if the increment of the number of patent applications is mostly due to a change in patent propensity, then the benefits in terms of increased incentives to innovate would not materialise; see CIFRA, *Challenging the ICT Patent Framework for Responsible Innovation: A Literature Review* (Madrid: CIFRA, 2016), <http://www.cifra-h2020.eu/results/>.

²⁶ K. Finley, “Open Source Won. So, Now What?” *Wired*, 11 August 2016, <https://www.wired.com/2016/08/open-source-won-now/>.

only on copyright show that patenting may not always be needed to recoup the costs of investing in software development.

Patents were originally conceived to provide incentives to innovate, but they also serve as a means to codify knowledge and support technology transactions. If the invention is sufficiently disclosed, patents also contribute to diffusion of knowledge. But they may also have important drawbacks and raise concerns. On the negative side, patents can be used to abuse monopoly power and lead to fragmentation of property rights over intellectual assets; they can block innovation and prevent freedom to operate; and they can add litigation and enforcement costs to R&D and innovation costs. All these concerns are valid for software-related inventions, but effects are likely to vary from ICT to pharmaceuticals, and given the pervasiveness of software they may spread to an increasingly large number of sectors.

As argued by Graham and Vishnubhakat:

Among the core drivers of software patent quality, there are perhaps two overarching considerations: 1) the correspondence between the scope of the patent disclosure—the explanation of what was invented and how it works; and 2) the scope of the patent claims—the boundaries of the legal protection provided to the patentee. For the patent bargain to work, to incentivize rather than to inhibit innovation, legal protection must be commensurate with scope of disclosure.²⁷

We can then conclude by making three recommendations to patent offices, for all patents in general and more so for software-related patents: (1) to increase transparency about the legal status of patents and their owners, so that patent fragmentation and opacity do not hamper the development of markets for technologies; (2) to maintain a high inventive step and strict non-obviousness test, in order to stop the grant of trivial patents; and (3) to ensure that all patent filings include sufficient information on how to implement the invention, so that patents are granted not to an "idea" or a "desideratum" but to inventions that can be implemented and help solve well-identified problems.

27 S. Graham and S. Vishnubhakat, "Of Smart Phone Wars and Software Patents," *Journal of Economic Perspectives* 27.1 (2013): 67–86, at 81.

Intellectual Property Management Challenges Arising from Pervasive Digitalisation: The Effect of the Digital Transformation on Daily Life

Peter Bittner

The digital transformation will affect all aspects of our daily lives. This includes our private lives and our professional lives. To name just a few examples, products and services become smart, processes in logistics and production become autonomous, and machine-generated data increase at an unprecedented rate and become more and more valuable when sense is made of them. Such trends lead to the development of new, often disruptive technologies paving the way for new data-driven business models.

The key enablers for the digital transformation are complex and include cumulative technologies. The latter consist of multiple layers of technology building on each other (technology stack) and containing intricate interdependencies. Important technologies in this respect include cyber-physical systems (CPS), where physical and software components are deeply intertwined, each operating at different spatial and temporal scales. CPS exhibit multiple and distinct behavioural modalities and interact with each other in myriad ways that change with context. Examples of CPS include smart grids, autonomous automobile systems, medical monitoring devices, process control systems, robotics systems, and automatic pilot avionics.¹

The communication between CPS components is enabled through the Internet of Things, understood as the network of physical devices, vehicles, and other items embedded with electronics, software, sensors, actuators, and connectivity that enable these objects to collect and exchange data. The Internet of Things allows objects to be sensed or controlled remotely across the existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy, and economic benefit, in addition to reduced human intervention.² In one aspect, the Internet of Things can be seen as a huge data-generation engine that provides data about the state of pretty much each and every "thing" connected to the Internet of Things.

The intelligence of CPS and the Internet of Things all comes through respective software applications that can process such data in near real time and make sense of the data to take control decisions at the device level or to generate recommendations for users of the software. Big data analytics applications can correlate seemingly non-related data to make predictions of all kinds of real-world events. These include, for instance, predicting the need to switch cycles of traffic lights, controlling autonomous cars, and determining shopping behaviour for a particular product in order to automatically refill the shelves at a retailer.

1. Owning the Profits

Companies aim to increase their footprints in digital space by trying to lead innovation in the relevant enabling technologies and/or digital business models. To own the profits, it is essential to own the intellectual property (IP) inherent to the innovations.³ Since a major part of these innovations is based on intelligent software solutions and data, new IP management challenges arise from the intangible nature of software and data. Modern software solutions often show a distributed character in that

1 "Cyber-Physical System," https://en.wikipedia.org/wiki/Cyber-physical_system.

2 "Internet of Things," https://en.wikipedia.org/wiki/Internet_of_things.

3 M. Blaxill and R. Eckardt, *The Invisible Edge: Taking Your Strategy to the Next Level Using Intellectual Property* (New York: Portfolio, 2009).

different parts of the software may be executed by different devices operated by different parties in different countries. A critical question is, therefore, who should own what and where? An even more difficult question relates to the ownership of data. How can you own data that are an important asset for a corresponding business model? We will discuss some of the appropriation mechanisms that are available to gain ownership of these intangible aspects of software innovation. Further, we will provide a short discussion on aspects of data ownership. The most relevant IP appropriation mechanisms for gaining ownership in software innovations include copyright, patents, designs, and database protection.

2. Copyright

Computer programs (as a work of literature) were included in the copyright laws in the early 1990s. The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) made software protectable by copyright in 1995. It confirmed that computer programs must be protected under copyright and that those provisions of the Berne Convention applying to literary works should also be applied to them. As software became a more and more important economic good at that time, an ownership mechanism was needed to provide an incentive for the innovator to invest in its creation. Copyright protects the literal expression of a computer program—that is, the code. The protection extends to the source code and binary code of a software program. However, it relates to a very specific implementation in a particular programming language. Copyright does not provide for ownership of the concepts of a software program that are implemented through a specific coding. That is, copyright cannot protect any functional behaviour of the software (i.e. its algorithms), and nor can it protect the architecture or interfaces of a computer system running the innovative software solution. As a consequence, competitors can legally perform a functional re-engineering of a software solution without having actual notice of the code and create a functional clone of this software solution.⁴

3. Patents

For decades, patent protection for so-called computer-implemented inventions has been available and most of the major patent offices grant such claims on software-related inventions when the software is used to solve a technical problem in a non-obvious manner. Claims for computer-implemented methods (i.e. algorithms) and computer program products (sets of computer-readable instructions that can perform the algorithm once executed by a processor) are possible in many jurisdictions. The key difference of a computer program product patent claim compared with a copyright claim to the code lies in the ability to claim the function (algorithm) of the software independently of its code implementation. That is, a patent claim on a computer program product provides protection for the functional behaviour of the software no matter how the function is finally implemented at the coding level. However, the hurdle to patent protection for software solutions is high because computer programs as such are excluded from patent protection in most countries. Therefore, a patentable software solution normally has to solve a technical problem with technical means to overcome this exclusion criterion. A further challenge in patent protection of software solutions is the distributed character often found in software systems. In the internet era, cloud computing and Internet of Things algorithms are usually performed by many different components, which may be operated by different

4 See *SAS Institute Inc. v. World Programming Ltd*, 2012, Court of Justice of the European Union, Case C 406/10.

parties even across multiple countries. Therefore, from the rights-holder's point of view, the art of claiming software inventions is to slice and dice such inventions into claims that are still infringeable and inventive.

4. Designs

Designs may be a useful means to protect user interface-related aspects of a software innovation. A certain user interface layout may be protected through an industrial design and can be used to prevent competitors from bringing confusingly similar layout designs to the market. However, it is to be noted that a user interface can be changed very easily in modern software deployment because it may simply involve changing a few lines of code and redeploying the amended software over the internet. Therefore, in many cases, design protection for user interface aspects can easily be circumvented just by redeploying the software without great effort.

5. Database Protection

A very important question in the age of data-driven business models is that of how to own the data on which the business model is developed. In fact, there is no real appropriation mechanism to gain ownership in data. De facto ownership may be gained through keeping the data secret, which, in many cases, would prevent a scalable business model. Of course, contractual agreements between specified parties can be drafted to rule on the allowed use of data by the licensee. The so-called *sui generis* database protection in the European Union can at least provide protection of the substantial parts of a database built by the innovator with substantial effort. However, one has to be careful when aggregating data that can be associated with an individual. In this case, data privacy laws prevent any ownership in such data. Even when aggregating non-personal data (e.g. machine data from a board computer), powerful correlation algorithms working on big data may be able to correlate such data with an individual person, thus transforming non-personal data into personal data.

6. Managing Intellectual Property Risks

The digital transformation changes processes in companies, as well as their product and service offerings across all industries. This creates a new IP management situation for many companies, especially in traditional, risk-averse industries (e.g. chemicals and pharmaceuticals). Products suddenly become smart in that they are delivered with software in one way or another. New business models arise in the digital world involving digital services. Production and logistics processes undergo disruptive digital redesigns enabled by Internet of Things technologies and robotics. Even the innovation processes in companies change dramatically by relying more and more on computer-aided innovation, with artificial intelligence applications developing rapidly.

The enablers for the digital offerings are the so-called complex cumulative technologies already mentioned. Such technologies are based on multiple layers of technology where each new layer builds on a previous layer. For example, when looking at a computer with a layered view,⁵ at the core of the computer there is a hardware layer that is able to process information expressed in bits and bytes in the registers of a processor.

5 N. Dale and J. Lewis, *Computer Science Illuminated*, 5th edn (Burlington, MA: Jones & Bartlett Learning, 2012).

A programming layer allows the hardware layer to be instructed to perform certain operations. The programming layer can be used to provide an operating system layer (system software) to hide complex and unimportant details of the internal structure of the computer architecture, to present important information to the user in an understandable way (e.g. graphical user interface), to provide a secure and safe environment in which to operate, to control the overall operation of the computer and manage its resources, and, last but not least, to facilitate access to those resources.

On top of the operating system layer, the application software layer is built. Application programs are used for problem-solving in more and more areas of daily life, including traditional technical and non-technical areas (e.g. banking, business, entertainment) but also completely new areas. The application is typically controlled through user interaction, and the result is typically directly visible to the end user.

A communication layer in addition to the programming layers allows computers to interact with other computers by providing the interfaces to establish the required connectivity. With every step in digital technology development, typically new layers are added to the technology stack. Such layers may also have interdependencies that can lead to very complex system architectures.

For companies doing business in traditional industry sectors with little or no focus on information technology (IT) and computer technology, using new technologies imposed by the digital transformation leads to situations where the old paradigms of exclusivity or freedom to operate no longer apply. Rather, IP risk management approaches seem to be more appropriate.

In technologies where an invention, such as a new compound, substantially shapes the final product (e.g. a new drug) without a significant number of technology layers in between, an innovation can often be clearly defined in terms of its boundaries. Sometimes these technologies (e.g. chemicals, pharmaceuticals) are referred to as discrete technologies. A thorough patent search will have been done to make sure the innovation will not conflict with existing patent claims of third parties (freedom to operate). The risk will be low that underlying technologies owned by somebody else are used unwittingly. In complex cumulative technologies, this is rather the rule than the exception. For example, when an innovation is made in the application layer (which is frequently the case in the smart product context), a patent search may reveal other IP rights targeting innovations in this layer. However, it is practically impossible to gain insights regarding the IP situation in the lower levels of the technology stack. Further, even within the same layer there are typically many claims floating around which pursue similar goals. It is to be expected that many patents exist that show overlaps in the scope of protection. In such a situation there is typically a high degree of dependency between the patents of different players. In other words, you may have a patent on a particular invention where somebody else has a patent on an invention that will necessarily be used for the implementation of your own invention, thus providing a bar to commercial use of your own invention.

IT and software are already an abstract technology. However, at the level of patent claims an additional layer of abstraction is introduced, which makes it increasingly difficult to derive the real boundaries of protection of particular patents. This problem is also referred to as the "lack of notice function" in the literature.⁶ As a consequence, even if a company acts in good faith and has made

6 J. Bessen and M.J. Meurer, *Patent Failure: How Judges, Bureaucrats, and Lawyers Put Innovators at Risk* (Princeton, NJ: Princeton University Press, 2008).

a product clearance search before going to market with a new product, in the digital world there is always a high risk that other IP rights (at other layers and even at the same layer) are infringed. This situation means abandoning an approach that gives the illusion of freedom to operate and rather moving to an IP risk management approach where risk strategies are defined in respect of certain IP portfolios and IP players. These risk strategies provide action templates on how to behave when a particular IP right owned by a particular player is discovered. Dependent on the associated risk, the range of actions may include anything from "ignore the IP right" to "take your product off the market."

7. Value Extraction and Commercialisation of "Digital Intellectual Property"

In traditional industries, IP was primarily used to gain exclusivity in certain aspects of an innovation. Such exclusivity could be used to prevent others from copying the innovation and to maintain a competitive advantage either by enforcing premium prices for the innovation (as nobody else was allowed to use it) or by generating additional revenues from licensing the innovation (for example, to extend market reach).

Looking at IP generated for complex layered technologies, it is quite unlikely that a new software solution can go to market without infringing dozens or even hundreds of patents in the various technology layers. In such a highly interdependent technology environment, it is vital to own the new aspects of the software solution that are attractive to other market players. However, the primary use of IP is not to exclude others from using your IP but rather to improve your power to negotiate access to others' IP portfolios at affordable prices.

Marshall Phelps asserts that "the world would be a lot better off if more companies would treat their IP primarily as a business and financial asset and not a litigation club for beating damage awards out of rivals."⁷ He has also argued that "We can't even build our own computers without other people's technology. The whole technology world is interdependent now and there's no going back. There's no way we're ever going to get out of the licensing game." He proposes using strong IP portfolios as a glue for collaboration between partners. Often such partners are also rivals, leading to situations of competition.

Another aspect of the commercialisation of digital IP is the coexistence between open source software (OSS) and proprietary software. OSS is software deployed under an open source copyright licence. More than 2,500 OSS licence types exist. Programmers using a piece of OSS code have the freedom to modify, change, and share the source code in accordance with the respective licence type. The free distribution requirement of such OSS does not allow a request for licence fees. The source code has to be accessible and can be modified, and these same modifications can be distributed as well.

Nowadays, almost every software solution makes use of OSS. Ever shorter development cycles and the increasing complexity of innovative solutions require the reuse of certain standard software functions that are often bundled in OSS libraries. Care must be taken when using OSS code in combination with proprietary software code. Some of the OSS licence types show a so-

7 M. Phelps and D. Kline, *Burning the Ships: Transforming Your Company's Culture through Intellectual Property Strategy* (Hoboken, NJ: John Wiley & Sons, 2009).

called viral character (i.e. copyleft licences, a play on the word "copyright"). This means that when proprietary software uses OSS under a viral licence, a so-called combined work is created that has to be relicensed under the same viral OSS licence. This can take a business model built on licensing revenues from proprietary software at risk. However, for internal use within a company where no further distribution of the generated software occurs, the use of OSS can be a valuable accelerator for digital projects at relatively low risk.

8. Conclusion

The digitalisation affecting all aspects of our life imposes tremendous challenges for companies in managing their IP. In particular, companies in more conservative industries need to recognise the need to change towards a more risk-oriented IP management approach. Building a valuable IP portfolio is becoming important for any company in improving its negotiation power to get access to others' technologies. This is vital in a highly networked and interdependent digital world. In this context, it is critical to understand which IP appropriation mechanisms are suitable for which types of digital innovation. In a digital world, as well, you have to own the IP if you want to own the profits.

Influences of Digital Transformation on Freedom-to-Operate Processes in the Chemical Industry

Alissa Zeller

1. Digitalisation in the Chemical Industry*

Digitalisation has reached all sectors of the chemical industry, from basic petrochemicals to crop protection. The value derived from digitalisation and thus the focus of individual projects differs along the value chain. At BASF, to give some examples, the Smart Manufacturing project builds on real-time analysis of data to improve plant processes and allow predictive maintenance; the Smart Supply Chain project employs cloud solutions to connect customers with BASF along the supply chain for optimised transparency; in the Smart Innovation project, big data analysis of published and unpublished research data increases the efficiency and effectiveness of research; and in the Digital Business Models project, the Internet of Things is used to create new services for customers.¹

All these initiatives build on and create information technology (IT) innovations. It is thus time for the chemical industry to implement digital intellectual property (IP) strategies. A search for information and communications technology patents filed by chemical companies between 2010 and 2015 reveals only moderate activity. Reliance, Sabic, Akzo, DSM, Monsanto, BASF, and Dow each filed between 5 and 20 patents during that time, and Bayer and Dupont between 20 and 60 each, with the highest number of patents in the agrochemical and pharmaceutical fields. Sinopec filed over 150 patent applications, with a focus on oil, gas, and mining and with China as the key country of protection.² These numbers are almost negligible when compared with IT patent filing activities in industries that entered the digital world earlier.

2. Key Differences between Chemical Inventions and IT Inventions

Patent protection strategies differ fundamentally between the chemical and the IT sectors, and consequently so do their patent landscapes. Innovation in chemical products generally requires significant financial investment and time. Patents ensure exclusivity and return on the high investment during long product life cycles. Typically, the exclusivity is achieved through a low number of patents per product filed in the key markets. Portfolios per product will include, for example, patents directed to the chemical molecule as such, its manufacturing process, and specific uses and formulations. Licensing is done, if at all, on a per patent basis.

IT technologies have a relatively short life cycle in comparison with chemical products. This holds for both hardware and software innovations. Those innovations, however, build on many basic inventions and technology from previous product generations. From an IP perspective, this leads to a situation where thousands of patents can affect even relatively simple IT solutions. Further differences between chemical and IT inventions are shown in Table 1.

* The content of this chapter is based largely on work by the BASF Digitalization Transformation in IP team, led by German and European patent attorney Dr Stephan Krieger of BASF SE Ludwigshafen. Special thanks to European patent attorney Peter Bittner of Peter Bittner und Partner, Walldorf, Germany, for his contributions.

1 BASF, Digitalisierung, <https://www.basf.com/de/company/about-us/digitalization-at-basf.html>.

2 The search included International Patent Classification, Cooperative Patent Classification, and European Classification System codes H04L, G06F, G06Q, and G06N.

Table 1. Overview of key differences between chemical and information technology (IT) inventions

	Chemistry	IT
Technology	Discrete	Complex cumulative
Number of inventions in product	Low	High
Distribution level	Low	High
Investment per innovation	High	Low
Product life cycle	Long	Short
Technical terminology	Standardised	Not standardised
Cross-licensing	Rare	Common (pools, standards)

These differences in patent landscapes correlate with different approaches to analysing and ensuring freedom to operate (FTO) regarding third-party patents. In the chemical industry, market players perform thorough FTO analyses to make sure they do not infringe patents of competitors or other third parties. For chemical products, a meaningful in-depth FTO analysis can be done because of the clearly defined product (chemical formula) and the limited number of patents per product. Both restrict the patent search and its analysis to a reasonable scope. For IT inventions, the key challenge in addition to the large number of patents for both a comprehensive search and its analysis is the lack of a standardised technical terminology. One and the same innovation can be defined in different terms. Thus, even if a potentially relevant patent can be identified, its scope of protection may be difficult to assess.

Consequently, the IT industry cannot and does not conduct in-depth FTO analyses for each product. The market players will prefer to respect third-party patents through a risk-based FTO analysis followed by cross-licensing of patent portfolios, including mutual balance payments.³ Since IT innovation requires access to basic technologies and those of earlier product generations as mentioned above, including those of competitors, participation in the software industry at a reasonable cost requires a substantial IT patent portfolio to get access to third-party technology via cross-licensing. Further patent landscape differences are listed in Table 2.

Table 2. Differences in the patent landscapes of chemical and information technology (IT) innovations

Chemistry	IT
1 patent per product	1,000 patents per product
Chemical company innovation owner	Innovation often made by IT partner
Patents very relevant	Patents slow; know-how protection essential
Established legal environment in many countries	Little case law; scope of patents difficult to assess; changing laws
Freedom to operate (FTO) key element of intellectual property and business strategy	Multilayer patent landscape; full FTO nearly impossible

3 The "patent wars" between Apple, Google, Samsung, and HTC Corporation represent more of an exception in the industry.

3. Impact of Digitalisation on Freedom-to-Operate Processes

FTO processes in the chemical industry are impacted by digitalisation at both ends of the product's development. Early on, the selection of ideas for further development in the laboratory will be facilitated by big data analysis. Intelligent "white space analysis" will already give an indication at this stage as to which fields are less crowded by third-party patents than others. In consequence, less critical chemical patents covering the finally developed product will come up in the search later on, which leads to an overall reduced FTO effort. This aspect of digitalisation certainly makes FTO tasks easier in the chemical industry.

At the late end of development, digitalisation introduces new FTO complexity, however. An increasing number of projects will include not only chemical inventions but also associated IT innovations. An established example is a new manufacturing process that includes steering algorithms. Upcoming examples are new applications of chemicals supported by technical services software. Accordingly, in the chemical industry, three ways to conduct FTO will exist. For chemistry-only inventions, a "classic" FTO will be conducted. For IT inventions, a risk-based FTO, including potential licensing, will be done. For mixed inventions, both kinds of FTO will be necessary.

4. A Risk-Based Freedom-to-Operate Approach for IT inventions

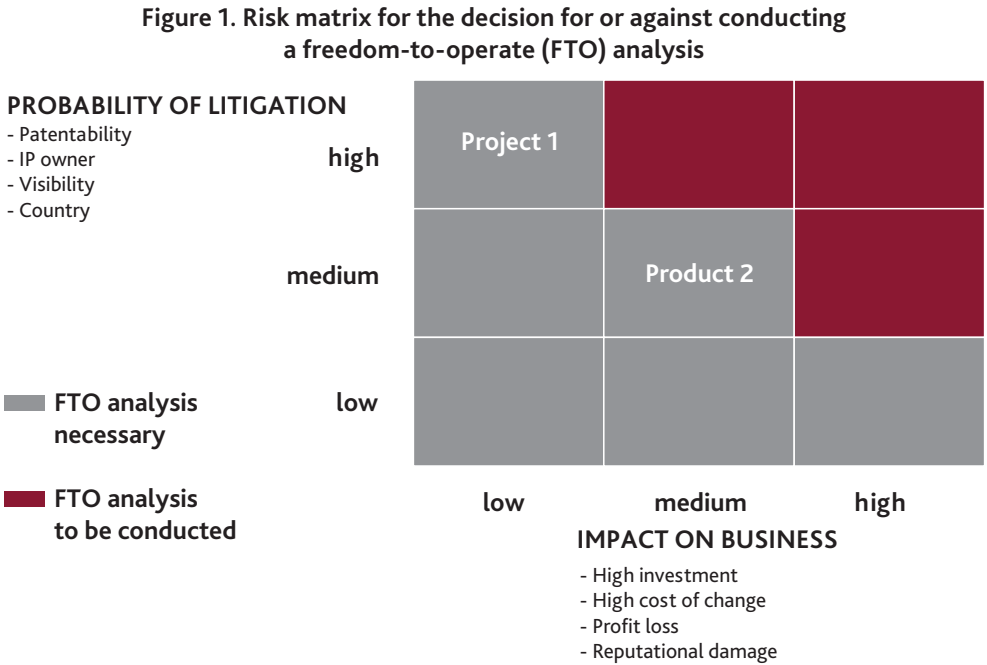
A risk-based FTO approach may contain the following steps:

1. White space analysis during the early research and development stage.
2. Risk analysis based on the technology and the competitive situation to decide for or against an FTO analysis.
3. Risk-adapted FTO analysis—that is, prioritised search and analysis.
4. Risk management.

The risk analysis leading to a decision for or against conducting an FTO analysis considers legal and economic factors: the probability of litigation and the impact on the business (Figure 1).

For a certain Project 1, for example, the legal risk assessment will include the patentability of the associated IT solution. With a restricted allowance practice of respective patent offices, few third-party patents are to be expected, and/or such patents can likely be considered invalid, reducing the probability that the patent owner will enforce them. Of further relevance for the legal risk assessment is the technology field of the project. If it is outside the field of competition between chemical companies, the risk of litigation may be lower, and potential conflicts may be more likely to result in licensing deals than end in court. Visibility of the IT innovation also has an influence on the litigation risk, as does the country of commercialisation.

The commercial risk assessment considers the investment to be made for a particular project, and the cost associated with a potentially necessary work-around in the light of third-party patents. Loss of profit risk assessment depends upon the absolute profit from the project, but also on the legal remedies for patent infringement in a country. An injunction against further commercialisation constitutes the greatest commercial risk, followed by expensive damage payments and attorney



fees. In Germany, for example, the risk of a preliminary injunction is comparatively high, whereas it is low in most other countries, including the United States. Damage payments will often be equivalent to licence fees.

Legal and economic risk assessment on an individual project basis will lead to a decision regarding whether or not to conduct an FTO search and analysis. In some cases, a small “test search” may facilitate the decision.

If the risk assessment calls for an FTO analysis, the search needs to be adapted to the complex cumulative nature of the IT patent landscape. A stepwise approach includes, for example, first getting an overview about the prior art published over 20 years back and excluding such prior art from the scope of the search. Second, it includes identifying the oldest patents potentially covering the product, or those oldest patents held by key competitors, since those presumably have the broadest scope and are most relevant. One may further restrict this analysis to patents held by key competitors, and check the validity of such cases only. The search specialist can also sort patents by their competitive impact, using for example the Patent Asset Index algorithm.⁴ As discussed, the terminology for IT inventions is not unified, so it is advisable to check some “quality hits” for relevance to the product and then maybe to refine the search. In summary, both the search and the legal analysis of the IT patents need to be prioritised to reduce the number of patents that are chosen to be analysed with full legal scrutiny.

4 Holger Ernst and Nils Omland, “The Patent Asset Index: A New Approach to Benchmark Patent Portfolios,” *World Patent Information* 33.1 (2011): 34–41.

5. Intellectual Property Risk Management

In the event that relevant third-party patents are identified in the FTO analysis, various options are available to manage and mitigate the associated risk. The traditional first step is a search for prior art. If the patent is invalid over prior art, a corresponding opinion without further action may be sufficient. Alternatively, or as part of such a strategy, opposition proceedings can be initiated.

The more radical consequences where third-party patents presumed valid are not open for licensing are a halt to the project or technical circumvention. The former is unlikely in the IT field as the latter solution typically has reasonable chances. In critical cases where actions by competitors are expected, mitigation measures can include avoiding high-risk countries, preparing a defence for litigation, and careful communication about the product.

The products for which the FTO analysis was conducted will eventually be sold or licensed to customers. It is important to manage the risk in such contracts to limit the liability in case of IP litigation. Indemnification caps are a typical way to do so, but restrictions by country, patent family, or field are also options at hand. In critical cases the parties will agree on responsibilities and termination rights in the event of litigation. Of course, contracts concerning IT development by external IT-product service providers should include clauses on respective liabilities as well.

Cross-licensing between companies has been mentioned as a typical instrument to manage FTO under IT patents and to get access to third-party technologies at a stroke. It is apparent that a risk-based FTO strategy as described will not be enough on its own to enable the chemical industry to also become a player in the digital field. Building strong IP assets of its own will be essential for in-licensing third-party technologies at a reasonable price and managing FTO at the same time. Filing a large number of patents (simply) to ensure FTO amounts to a paradigm shift in the chemical industry, and corresponding implementation may take some time.

A specific cross-licensing initiative is the License on Transfer (LOT) Network,⁵ a community of companies aimed at combating patent trolls by cross-licensing patents. "Patent troll" is a somewhat controversial term mostly used to define non-practising entities that acquire patents solely to make a business out of enforcing them. LOT was initiated by Google in 2014 and has gained over 70 members, mostly from the IT, automotive, and finance industries, with 0.8 million patents on the cross-licensing list. The annual fee is zero to US\$ 20,000, depending on the size of the company. The licence scheme provides that, if—and only if—any of the LOT members sells a patent to a patent troll, the other LOT members are granted an automatic royalty-free licence under this patent. The LOT licence does not affect the members' rights to sue each other, or to sell the licensed patents.

In the chemical industry, so-called "defensive publication" represents an alternative strategy to ensure FTO. Typically, patent applications or other documents describing the prospective market product are published via specific websites such as IP.com. The aim is not to obtain a granted patent but rather to create prior art for third parties, hindering them from filing patents blocking the product. In the IT field, it is questionable whether defensive publication can be a strategy to ensure FTO. The number of patented inventions is so high—especially in the United States—and they address so many specific aspects that it is unlikely that publication like this would prevent more

5 LOT Network, <http://lotnet.com/>.

patent grants. This is even more the case as IT patents are normally filed within a very short time after the idea is generated, with a chemical company unlikely to be the first to have had that idea. In addition, patent applications are generally filed without a prior art search, and often proceed to grant without an holistic search by the patent office. Another argument against defensive publication as an FTO strategy is that it would reveal details about the technology used, inviting patent trolls to collect patents for later attacks.

The use of OSS would significantly decrease the risk of patent infringement, at least regarding the software components of a product. This can be a complementary strategy in areas where a company does not have an interest in building an IP position of its own—that is, for “internal use only” scenarios or where exploitation through licensing of the software component is not part of the business model.

6. Outlook

This chapter has described how the chemical industry assimilates FTO analysis rules for IT innovations. Other industries have already taken corresponding steps, including the pharmaceutical and automotive sectors. While this development has focused on the way to employ traditional search and analysis methods for a risk-based FTO assessment, the next big change will come from new search and analysis methods themselves. Artificial intelligence and big data are the digital backbone technologies of new software supporting the search specialist and patent lawyer. The first tools are already emerging on the market for white space analysis, and development is under way for intelligent analysis of invalidity, infringement, case law, and even legal risk. Reliable tools of this sort may be available for the chemical industry somewhat later than for other industries—the chemical language has hundreds of millions of words in each individual language, which is a design challenge for artificial intelligence software—but it is prudent to think about the legal implications now. Questions to be answered include: What is the legal relevance of computer-generated mass patent filings covering computer-identified white space areas?⁶ Will such patent applications count as prior art, and will they be patentable? Who is the corresponding inventor?⁷ To what extent can an FTO conducted by artificial intelligence tools be a legal work product? As a first step, we can try to answer these questions by interpreting the law. The fundamental technological changes ahead of us, however, can be expected to give rise to a call for legislative changes.

6 “Algorithmic patenting” has been used to create short descriptions or claims by combining elements of published documents employing permutations and linguistic manipulations. The aim to date has mostly been to create prior art through defensive publication—that is, to prevent either competitors or patent trolls from obtaining patents on the environment of certain subject-matter. Filing a large number of patents for claims like these that are not necessarily viable does not have a very favourable cost–benefit ratio at present. Once the algorithms become smart enough to suggest non-incremental inventions, this will change. For further background, see for example “Cloem,” <https://en.wikipedia.org/wiki/Cloem>; “All the Claims,” <http://alltheclaims.com/>; and “All Prior Art,” <http://allpriorart.com/>.

7 See, for example, Ryan Abbott, “Autonomous Machines and Their Inventions,” *Mitteilungen der deutschen Patentanwälte* (2017): 429–437.

PART TWO

Regulating and Using Big Data in the Digital World

Big Data: Ownership and Use in the Digital Age

Reto Hilty

1. Introduction

"Big data" is just one of several ways to describe the fact that we are currently witnessing a new "industrial" area, characterised by business models that are based on huge volumes of data. Other common expressions nowadays—such as "Industry 4.0," "Digital Economy," "Internet of Things," "Internet of Everything," "Industrial Internet," and "Data-Driven Economy"—try to address further, additional elements, but "data" are always the main focus of the discussion.

Those data in a sense constitute the third dimension within an ongoing industrial revolution beginning in the middle of the twentieth century. The first dimension encompassed the underlying information technology as such, most importantly computer technology, allowing electronic data processing as well as data storage. The second dimension was characterised by the connection of computers and the transportation of data; it initiated the era of the internet. In the third dimension, the (digital) content moves to the centre; data as such are the focus. Of course, the evolution of this third dimension happened gradually, since "data" always took centre stage in this ongoing digital revolution. What makes the difference, however, and characterises the third dimension, is the volume of data ("big data") as well as the nature of the data involved—we will come back to that.

Not surprisingly, the value of such data is esteemed as extremely high, and corresponding images have been conjured up, in particular data as the "mineral oil" of the digital economy. Others immediately objected to that comparison; mineral oil—or at least access to sources of oil—may be monopolised. Instead, data were described as the "oxygen" of the digital economy. In fact, oxygen is the indispensable resource for any life and, as a matter of principle, freely accessible. Data have also been seen by the European Commission as "a catalyst for economic growth, innovation and digitisation across all economic sectors," particularly for small and medium-sized businesses (and start-ups) and for society as a whole.¹ Alternatively, data might be grasped as (part of) the infrastructure of the digital economy: the "data-driven" economy. Following that logic has a particular significance because it leads us to the insight that "data" possibly are not just a private matter; at least public infrastructure obviously needs to be a concern of public authorities.

2. Expectations

In fact, public authorities are tempted to "regulate" the digital economy. In particular, the European Commission seeks regulatory measures; its major intention is to enhance the growth potential of the emerging data economy. In the end, the world is to become smarter—the sooner, the better.

Visions focus on "smart cities," for example optimising the use of scarce resources (such as energy); "smart traffic" measuring road capacities, channelling flows of traffic, pooling travellers; "smart factories," in particular robot-controlled production lines, need-based supply of commodities, optimising distribution channels, and so on; or "smart homes," for example heating systems, fridges automatically purchasing missing food and beverages, surveillance systems, and the like. Regarding "smart products," the prime example is cars, in countless aspects, above all automated driving, traffic management systems, maintenance signalling, and dynamic insurance models. But also "smart wearables" are discussed, for instance communicating with each other or the environment, or

¹ See European Commission, "A Digital Single Market Strategy for Europe," COM(2015) 192 final, 14.

"smart agriculture," focusing on animal husbandry, soil management, in particular fertilisation, and other things. A great potential is also anticipated from "smart medicine," for example personalised drugs or therapies, with surveillance systems for effects and (unwanted) side effects, or measures to prevent infectious diseases.

This digital revolution is happening globally, and it is indeed not unjustified for the European Commission to worry about the leadership of the European (digital) economy. The European Commission clearly expressed this concern in "A Digital Single Market Strategy for Europe"² and its "Free flow of data" initiative.³ One important milestone had already been set in 2014, with the European Commission communication "Towards a Thriving Data-Driven Economy,"⁴ which was followed by an impact assessment.⁵ A communication of the European Commission, "Building a European Data Economy," followed on 10 January 2017,⁶ accompanied by a wide public consultation.⁷ On 13 September 2017 the European Commission also launched its Proposal for a Regulation on a framework for the free flow of non-personal data in the European Union.⁸

Whether leadership of European (digital) industries can be achieved with (European) leadership in legal regulation, however, is another question. Regulation—ultimately legal intervention into market activities—is never an aim in itself but is justified only on condition that positive impacts can reasonably be expected—in this case, above all a stimulation of the data-driven economy.

It is, however, remarkable that the data-driven economy is already prospering today, with virtually no (specific) legislation. It seems that the best incentive for an entrepreneur—namely the prospect of profits—works in the digital environment just as well as in the analogue world. It seems the industries concerned learned quickly (and are still learning) how to deal with the phenomenon of "big data," and in particular how to "commercialise" (the value of) data. In view of that, it is legitimate to ask to what extent, if at all, state regulation might indeed (further) stimulate and sustain that naturally occurring process of adaptation from the traditional industries to the digital industrial age.

3. Need for Regulation ... ?

The European Commission seems to have one major and one less clearly expressed concern. The major concern is also—directly—addressed in the title of this chapter: who "owns" the data? Asking

2 European Commission, "A Digital Single Market Strategy for Europe," COM(2015) 192 final.

3 Ibid., 15.

4 European Commission, "Towards a Thriving Data-Driven Economy," COM(2014) 442 final.

5 European Commission, *European Free Flow of Data Initiative within the Digital Single Market* (Brussels: European Commission, 2016), http://ec.europa.eu/smart-regulation/roadmaps/docs/2016_cnect_001_free_flow_data_en.pdf.

6 European Commission, "Building a European Data Economy," COM(2017) 9 final.

7 European Commission, "Public Consultation on Building the European Data Economy" (Brussels: European Commission, 2017), <https://ec.europa.eu/digital-single-market/en/news/public-consultation-building-european-data-economy>. See also European Commission, "Summary Report of the Public Consultation on Building a European Data Economy" (Brussels: European Commission, 2017), <https://ec.europa.eu/digital-single-market/en/news/summary-report-public-consultation-building-european-data-economy>; and European Commission, "Synopsis Report Consultation on the 'Building a European Data Economy' Initiative" (Brussels: European Commission, 2017), http://ec.europa.eu/information_society/newsroom/image/document/2017-36/synopsis_report_-_data_economy_A0EFA8E0-AED3-1E29-C8DE049035581517_46646.pdf.

8 European Commission, "Proposal for a Regulation of the European Parliament and of the Council on a Framework for the Free Flow of Non-personal Data in the European Union," COM(2017) 495.

the question that way, however, is already suggestive, because the primary question should be: can (or should) data be “owned” at all?

The second concern is—indirectly—addressed in the title of the chapter; it is the word “use” of data—or, one might rather say, “access” to data. The relevance of these two issues should not be underestimated. We might now be facing a landmark decision of similar significance to the one of more than 100 years ago, related to the question of whether “innovation” should be subject to “ownership.” The question was: do we need patent law? The concerns and arguments expressed at that time—for or against patent law—were remarkably similar to our discussion on ownership of, and also on access to, data.

Certain problems with patent law that we are observing today (more than ever before) advise us to be cautious with regard to the creation of “data ownership.” The establishment of legal exclusivity might produce unwanted, dysfunctional effects; instead of fostering the digital economy, certain business models might even be impeded.

We should also not ignore the fact that the discussion on “ownership” of data is to a great extent limited to Europe. This should be a reason for scepticism: is it really wise for Europe to take regulatory “leadership” in that respect? Why is legal protection not a concern of our main rival, the United States? Is it possible that Europeans are afraid of US power in the digital economy? The majority of the dominating drivers of the digital economy are indeed US companies (the Googles, Facebooks, WhatsApps, Amazons, and many others). And it is certainly true that those companies would not be as successful as they are if they did not have access to “big data”, or, more precisely, to *our* data ...

But is, then, “ownership” of our data the right answer to the challenge the European digital economy is facing vis-à-vis the US digital economy? It might be premature to provide conclusive answers to such questions today. And this short overview does not allow us to go into detail. But we can at least hint at some considerations.

3.1 Ownership

Already the term “ownership” raises numerous questions. This becomes visible with the attempt to find alternative terms; they may exist—property, possession, exclusivity, control, sovereignty, responsibility—but they all (legally) mean something different, in particular in relation to data.

The European Commission, in its communication of January 2017,⁹ seems to use the term with two different meanings: (1) a right *in rem*, leading to “property” in data, meaning an exclusive right characterised by an *erga omnes* effect. Such a right typically is transferrable, and licences to third parties can be granted, contractually allowing them the usage of data; beyond that, it necessarily involves measures of enforcement against any third party using data without authorisation, including the right to claim damages for unauthorised uses. (2) A purely defensive right for the de facto holder of data, characterised by a right to sue third parties in case of illicit misappropriation of data. This approach resembles “possession” rather than “ownership;” it is comparable to the possession of (as such not protected) know-how, and the concept of legal protection may be similar to the one applied in Directive 2016/943 on the protection of undisclosed know-how and business information (trade secrets) against their unlawful acquisition, use and disclosure.

9 European Commission, “Building a European Data Economy,” COM(2017) 9 final.

These two approaches are meant as ways forward *de lege ferenda*. This triggers the question concerning legal protection *de lege lata*. An answer to the question of legal protection as it exists requires more profound analyses and fundamental research; at present, however, three remarks should be made in that context.

First, protection of data with an *erga omnes* effect (in terms of "property") already exists to a certain extent. Directive 96/9 on the legal protection of databases stipulates a protection "sui generis" against the "extraction" of "parts"; such parts can be understood as "data." However, even without going into detail, Directive 96/9 is unlikely to be helpful in our context, in particular because it does not focus on data as such. Nevertheless, it may teach us another important lesson. The Directive was enacted based on purely theoretical assumptions; chief among these was the belief that legal protection is required to stimulate investments in the establishment of databases. An evaluation of 2005, however, revealed that if an effect of the "sui generis" right was measurable at all, it was negative rather than positive.¹⁰ The lesson we can learn from this is that mistakes in legislation on intellectual property can happen—but they should not be repeated.

Second, as to a defensive approach, data—*de lege lata*—do already play a tremendous role in European law; however, this is limited to "personal data," in terms of "data protection" as an element of the personality right. Most importantly the General Data Protection Regulation 2016/679 (GDPR), applicable from 25 May 2018, plays a fundamental role (see also Section 4 of this chapter), but it is doubtful whether it provides an adequate legal framework beyond individual interests in the data-driven economy.

Third, the above-mentioned Directive 2016/943 on trade secrets protection deserves more attention as regards the question of whether data in terms of "information" are already (*de lege lata*) protected, at least to a certain degree, based on a defensive-rights approach. This question also requires deeper legal analysis, but this is not the place for it.

However, the second and third layers of protection *de lege lata* reveal one thing very clearly: context matters. The term "data" by no means provides a clear conception of the subject matter of (possibly required) legal protection. Data may be of a very diverse nature, and the nature of data decisively impacts the question of "ownership." Very roughly speaking, we may distinguish three categories of data:

- Data can be of a purely technical or factual nature, such as machine data (e.g. engine temperature), meteorological data, market and stock exchange data, and so on. In certain cases, in particular if data provide "information" or "know-how," then it is not difficult to imagine an application of Directive 2016/943 on trade secrets protection; at the same time, we should bear in mind that this Directive was not drafted with a view to protection of data as such.
- The term "personal data" used in the GDPR possibly does not describe the meaning of the second category very clearly; the French term "*données à caractère personnel*" might be more expressive, whereas the German term "*personenbezogene Daten*" explains even more precisely that these data involve a "reference" or "connection" to individual people. Examples of "personal

¹⁰ European Commission, *First Evaluation of Directive 96/9/EC on the Legal Protection of Databases* (Brussels: European Commission, 2005), http://ec.europa.eu/internal_market/copyright/docs/databases/evaluation_report_en.pdf; currently this Directive is under review again.

data" are similarly uncountable as the ways in which they can be used (and abused); just think of health data (irrespective of whether such data relate to the pharmaceutical sector, lifestyle products, insurance matters, or other areas), consumer behaviour (internet searches, use of credit cards, purchasing behaviour influenced by advertising), conduct on social networks (thus expressing political preferences, spreading propaganda, and so forth), and individual movements (measured by mobile telephones, used in traffic applications, and many other contexts).

- The third category somehow stands between the first two, and it seems hard to find an appropriate term in English for the German term "*personenbeziehbar*." This basically means that data as such are not related and are not directly "attributed" to an individual person, but the relation to a person can (more or less) easily be produced. This third category is particularly important; a majority of applications are based on such data. Also, in this context the GDPR plays an important role—but it might be a dangerous one (see Section 4 of this chapter).

One example is most instructive in explaining why this category of data plays a paramount role: it involves navigation apps showing the flow of traffic. The colour green is used for flowing traffic, orange for slow-moving traffic, and red to signal a traffic jam. This information is not collected based on hundreds of helicopters or drones flying over the country, sending pictures to traffic control centres. Instead, this information is generated by correlative movements of the mobile telephones of the car drivers passing through the same positions; Apple, Android, and all other applications are based on similar technologies. It goes without saying that individual drivers could be identified; their data could for instance be connected with data produced by the car itself, or advertisements could be sent to them, for example for nearby restaurants when there is a traffic jam. But this is not the intended purpose of such apps; the identity of the driving person does not matter for the functioning of the navigation app.

Depending on the category we are talking about, data can be subject to fundamentally different conditions, whether in terms of collection, processing, function, or downstream uses of data; in particular, the interests of potential stakeholders differ tremendously. In view of that, providing an answer to the question of data "ownership" is not easy—even if we agreed on the need of legal protection. For instance, in the case of the traffic app, who should be the "owner?" Should it be the car producer, the supplier of the sensor or control unit, the app producer, the service provider, the car driver—or even perhaps another party? Or would such a complex setting entail a kind of "co-ownership?" What would "ownership" mean, say, in the context of traffic information apps? Would anybody have an interest in prohibiting the use of such data? Apart from that, if ownership is to have the purpose of the monetisation of data, who should pay whom for what in connection with such data, and how much?

3.2 Access

In fact, the value of certain data is obvious, but it is not necessarily (or only) individual data that may have a value. In the case of traffic data, for instance, only a smart combination of (big) data matters; at the same time, it is obvious that access to such data is of crucial importance. In particular, independent suppliers of a service or product—those players who may not directly seize data from drivers' mobile telephones—depend on access to relevant data.

But individual data—such as health data—may also be of interest beyond the patient concerned (the one who “produces” the data), or beyond a supplier of a health service who is in the position of picking up such individual data directly from the patient. Imagine, for instance, that a patient is under direct medical treatment by a pharmaceutical company (in fact, individualised, direct treatment will be the future of healthcare, according to this industry). At the same time, this patient may be in need of some other medical treatment—possibly in an emergency—from an independent medical doctor. This other doctor clearly needs to have adequate information regarding the initial, ongoing treatment in order to judiciously combine different drugs and avoid side effects. Or imagine a farmer in relation to a supplier of specialised farm machinery that collects data (under the supplier’s control) on the soil quality on the farm. If the farmer needs fertiliser sold by an independent company, information on the farm’s soil is necessary to identify the appropriate product.

In short, access to data may be an issue of major relevance, irrespective of the question of “ownership” in terms of legal protection, simply because in most cases practical circumstances exclude third parties from the information contained in such data when it is under the factual control of other players. But we are miles away from uniform, comparable situations. Therefore, even if legal intervention to provide access should be considered, it is hardly imaginable that a one-size-fits-all approach could be found.

One fundamental question in that context is, of course, whether antitrust law can play a guiding role as to provision of access. This question deserves serious attention; a position paper of the Max Planck Institute for Innovation and Competition of 16 August 2016, however, concludes that antitrust law in most cases is not tailored in a way to address the issue of access to data. Rather, if at all, sector-specific regulations might be required.¹¹

4. ... or Need for Deregulation?

Legal rules on “ownership” and “access”—if such rules do in fact provide a sustainable environment and create incentives for the (European) digital economy—are not the only way forward, however. Public authorities could also consider alternative regulatory or supportive measures. In fact, the issue of “big data” is not that new, as it has (at least indirectly) been addressed in earlier legislation of the European Union, although in a rather specific field. Directive 2003/98 on the reuse of public sector information focuses on data under the control of public authorities such as meteorological data, traffic data, topography measurement data, and so on. It goes without saying that such data may be of the highest relevance for countless apps, and in particular for new players in the related markets. This Directive, however, in the first instance addresses antitrust concerns; all private entities are to have access under equal conditions.

But states could do more—just think of tax regulation, simplified public administration (e.g. for start-ups), school and university education, and much more. Generally speaking, and from a wider perspective, simple *de*-regulation might be the right answer to further stimulate initiatives in the data-driven economy. In fact, listening to the industries involved, legally protected “ownership” seems not to be a concern; they largely rely on the factual possibilities allowing them to keep their data exclusive (as earlier empirical analyses confirmed). Beyond that, industries are rather reluctant

¹¹ For details, see “Data Ownership and Access to Data,” www.ip.mpg.de/en/link/positionpaper-data-2016-08-16.html.

about the establishment of access claims—maybe because they are aware that there is no one-way system; the claimant in one case might be the defendant in another, being directed to provide access to competitors.

If (certain) industries express any concerns related to the digital economy, it is that the GDPR might threaten (at least some) existing and, above all, new business models. This issue should be a primary concern for the European Commission. This is not the place to discuss details, but at least some incomplete reflections might shed some light on this issue.

What may be the most important concern is the term "identifiable natural person" in the definition of Article 4(1) of the GDPR 2016/679:

..."personal data" means any information relating to an identified or identifiable natural person ("data subject"); *an identifiable natural person is one who can be identified, directly or indirectly, in particular by reference to an identifier such as a name, an identification number, location data, an online identifier or to one or more factors specific to the physical, physiological, genetic, mental, economic, cultural or social identity of that natural person* [emphasis added].

The emphasised words are of particular relevance in view of a recent ruling of the Court of Justice of the European Union,¹² relating to the previous Directive 95/46 Article 2(a), which, however, was similarly adopted in the GDPR:

... must be interpreted as meaning that a dynamic IP address registered by an online media services provider when a person accesses a website that the provider makes accessible to the public constitutes personal data within the meaning of that provision, in relation to that provider, where the latter has the legal means which enable it to identify the data subject *with additional data* which the internet service provider has about that person [emphasis added].

Other provisions might be incompatible with most business models of "big data," for instance the provision on "data minimisation:" "[Personal data shall be] adequate, relevant and limited to what is necessary in relation to the purposes for which they are processed."¹³ Beyond that, very far-reaching information duties,¹⁴ a right to rectification,¹⁵ or a right to erasure¹⁶ might prevent potential developers from investing resources in new business models.

Of course, GDPR 2016/679 has a reasonable background, and the concern is not that personal data might in any way become the subject of abusive behaviour. However, the threat potential, with administrative fines of up to €20 million or up to 4 percent of total worldwide annual turnover (whichever is higher), might stifle a number of possible and useful new applications. The Republican Party in the United States has gone in the other direction. A regulation of the Federal Communications Commission—established in October 2016 under former President Obama—was repealed in 2017. This allows cable companies and wireless providers to sell (and monetise) client data on online

¹² C-582/14, 19 October 2016—Breyer, para. 31 to 49.

¹³ Article 5 para. 1(c) GDPR.

¹⁴ See Article 15 GDPR: Right of access by the data subject.

¹⁵ Article 16 GDPR.

¹⁶ The so-called "right to be forgotten" in Article 17 GDPR.

activities (such as browsing history, shopping habits, and other information). It is obvious that this is not what Europe should do; but a greater sense of proportion seems recommendable. One way could be to incentivise the transformation of personal data into pseudonymous data and to clearly exempt corresponding business models from the GDPR.

5. Conclusions

If there are serious doubts about the need for legal protection of "ownership" in terms of "property" (ultimately leading to a new IP right), this does not necessarily exclude purely defensive approaches. In certain, rather particular cases, specific protection against misappropriation of de facto excluded, but possibly not sufficiently protected data might enhance or facilitate data transactions.

But a one-size-fits-all approach, whether addressing protection or access concerns, is unlikely to produce positive effects overall. This is due, above all, to the scale of the dynamics of the digital economy. State regulation will always lag behind the development of new business models, and ultimately enhance the risk of producing undesirable, dysfunctional effects.

An approach worth considering, in contrast, might be the definition of certain policy targets for the industries concerned, while leaving them to decide how to achieve these targets. In fact, "(regulating) self-regulation" might be the most promising legislative tool for the digital economy—at least at our current stage of knowledge.

Crafting a Text and Data Mining Exception for Machine Learning and Big Data in the Digital Single Market

Christophe Geiger, Giancarlo Frosio, and Oleksandr Bulayenko

1. Introduction

New data are created by the quintillions of bytes every day.¹ This explosion of data makes possible fast-developing machine learning and artificial intelligence technology. These technologies thrive on repurposing and processing big data streams. In the big data era, orienting within this magma of online data has become an extremely complex but crucial task, leading to complex issues in terms of regulation of this new environment.² According to the European Commission, the European data economy—also frequently referred to as the “fourth industrial revolution”³—is a great opportunity for growth as “Big Data considerably improves decision-making capabilities and, ultimately organizational performances.”⁴ Text and data mining (TDM) thus serves as an essential tool to navigate the endless sea of online information in search of this invaluable treasure that big data might hold for the European economy.⁵ Some studies have estimated that it could create value in excess of hundreds of billions of euros for Europe if data can be used more effectively.⁶

The European Union (EU) would like to promote measures to unlock TDM potentialities. The Proposal for a Directive on Copyright in the Digital Single Market (DSM Draft Directive) aims to improve access to protected works across borders within the digital single market (DSM) to boost research and innovation.⁷ In particular, the proposal would like to introduce a new mandatory limitation for TDM.⁸

In this chapter we assess this proposal against the international and European copyright framework and evaluate room for possible improvement. We conclude by inviting EU policymakers to significantly broaden the scope of the limitation in order not to prevent European DSM players from engaging safely in ground-breaking technological innovation, such as machine learning, neural networks, and artificial intelligence, through the exploitation of big data's riches.

2. Is There Conflict between Intellectual Property Protection and Text and Data Mining?

TDM refers to a research technique to collect information from large amounts of digital data through automated software tools.⁹ It involves copying substantial quantities of materials to extract the data

- 1 See Jeff Schultz, “How Much Data Is Created on the Internet Each Day?,” *DZone*, 16 October 2017, <https://dzone.com/articles/how-much-data-is-created-on-the-internet-each-day>.
- 2 On this important topic, see Reto Hilty's chapter in this publication.
- 3 See, for example, Yann Ménière and Ilja Rudyk's chapter in this publication.
- 4 European Commission, *The European Data Market Study: Final Report* (Brussels: European Commission, 2017), 5.
- 5 Xindong Wu, Xingquan Zhu, Gong-Qing Wu, and Wei Ding, “Data Mining With Big Data,” *IEEE Transactions on Knowledge and Data Engineering* 26 (2014): 97.
- 6 James Manyika, Michael Chui, Brad Brown, Jacques Bughin, Richard Dobbs, Charles Roxburgh, and Angela Hung Byers, *Big Data: The Next Frontier for Innovation, Competition, and Productivity* (San Francisco, CA: McKinsey Global Institute, 2011).
- 7 European Commission, Proposal for a Directive of the European Parliament and of the Council on Copyright in the Digital Single Market, COM(2016)593 final, 2016/0280, 14 September 2016.
- 8 *Ibid.*, Arts 3–6 and 7–9. For a detailed analysis, see Christophe Geiger, Giancarlo Frosio, and Oleksandr Bulayenko, “The Exception for Text and Data Mining (TDM) in the Proposed Directive on Copyright in the Digital Single Market: Legal Aspects,” Research Paper No. 2018-02 (Strasbourg: Center for International Intellectual Property Studies, 2018), [http://www.europarl.europa.eu/RegData/etudes/IDAN/2018/604941/IPOL_IDA\(2018\)604941_EN.pdf](http://www.europarl.europa.eu/RegData/etudes/IDAN/2018/604941/IPOL_IDA(2018)604941_EN.pdf).
- 9 For a reference to possible multiple TDM and data analysis techniques, see, for example, Jiawei Han, Micheline Kamber, and Jian Pei, *Data Mining: Concept and Techniques*, 3rd edn (Waltham, MA: Morgan Kaufmann, 2011).

and recombining them to identify patterns in the final output.¹⁰ Obviously, there might be conflict between intellectual property protection and TDM techniques.

One of the fundamental principles of copyright law is that data are as such not protected; copyright protects only the creative expression or form, rather than the information incorporated in the protected work.¹¹ Thus, TDM should in principle not be covered by any exclusive intellectual property rights (IPR), both copyright and other sui generis rights. However, at some point, during the chain of activities enabling TDM research, technically some IPR-relevant actions might be necessary. Therefore, in the absence of a specific permission, TDM can lead to an infringement. In particular, TDM can involve some activities encroaching on the exclusive copyright and database rights provided by Directive 2001/29/EC and Directive 1996/9/EC. In this respect, the TDM process might become relevant for intellectual property, depending on the use of the existing sources, technical tools, and the extent of the mining process.

TDM usually involves some copying, which even in the case of limited excerpts might infringe the right of reproduction.¹² TDM activities can concern text or data, both of which can be covered by intellectual property protection, both copyright and database sui generis rights, or they can be outside the scope of protection (e.g. lacking originality or being in the public domain). Only TDM tools involving minimal copying of a few words or crawling through data and processing each item separately could be operated without running into a potential liability for copyright infringement. This follows from the fact that "[t]ext and data mining may also be carried out in relation to mere facts or data which are not protected by copyright and in such instances no authorisation would be required."¹³ Works and other subject matter not protected by copyright or sui generis rights can be mined freely.¹⁴

Instead, any reproductions resulting in the creation of a copy of a protected work along the chain of TDM activities might trigger copyright infringement. In this respect, pre-processing to standardize materials into machine-readable formats might trigger infringement of the right of reproduction.¹⁵ Likewise, the uploading of the pre-processed material on a platform—which might or might not occur, depending on whether the TDM technique makes use of TDM software crawling data to be analysed directly from the source¹⁶—might also violate the right of reproduction. Mining (the stage of the TDM process

10 See, for example, Diane McDonald and Ursula Kelly, *The Value and Benefit of Text Mining to UK Further and Higher Education: Digital Infrastructure* (London: JISC, 2012), <http://bit.ly/jisc-textm>; and Jean-Paul Triaille, Jérôme de Meeûs d'Argenteuil, and Amélie de Francquen, *Study of the Legal Framework of Text and Data Mining (TDM)* (Brussels: European Commission, 2014), 28.

11 For a fundamental reflection on this principle, see the seminal work by P.B. Hugenholtz, *Auteursrecht op Informatie* (Deventer: Kluwer, 1989).

12 See Court of Justice of the European Union, Case C-5/08 *Infopaq International A/S v. Danske Dagblades Forening*, 2009, ECLI:EU:C:2009:465, §§ 54–55, finding that an excerpt as short as 11 words might be protected.

13 European Commission, Proposal for a Directive of the European Parliament and of the Council on Copyright in the Digital Single Market, COM(2016)593 final, 2016/0280, 14 September 2016, Recital 8.

14 With regard to mining public-sector information, the ongoing review of Directive 2013/37/EU of the European Parliament and of the Council of 26 June 2013 amending Directive 2003/98/EC on the reuse of public-sector information might clarify how to facilitate in practice TDM of public-sector records.

15 See Directive 2001/29/EC of the European Parliament and of the Council of 22 May 2001 on the Harmonisation of Certain Aspects of Copyright and Related Rights in the Information Society, 2000 OJ (L 167) 10–19, Art. 2.

16 Jean-Paul Triaille, Jérôme de Meeûs d'Argenteuil, and Amélie de Francquen, *Study of the Legal Framework of Text and Data Mining (TDM)* (Brussels: European Commission, 2014), 28.

where data are finally extracted) can also infringe upon the right of reproduction, depending on the mining software deployed and the character of the extraction. For example, there are extraction techniques that would reproduce parts of the work so minimal as to fall below the threshold of copyright infringement.¹⁷

Again, TDM might involve the reproduction, translation, adaptation, arrangement, and any other alteration of a database protected by copyright, which means the original selection and arrangement of the database's content.¹⁸ For example, pre-processing for extraction might cleanse from a database portions and data that are irrelevant for data analysis. In this respect, pre-processing might violate both the right of reproduction and the right to make adaptations and arrangements.¹⁹

Moreover, TDM might infringe sui generis database rights, in particular the extraction, and to a minor extent the reuse, of substantial parts of a database. In this context, even if extraction does occur without reproduction of the original materials, extraction itself would infringe upon the exclusive rights provided to the database owner.²⁰ In this regard, the Court of Justice of the European Union (CJEU) has provided that the transfer of data from one medium to another and its integration into the new medium constitutes an act of extraction.²¹

Finally, it is to be noted that the TDM output should not infringe any exclusive rights, as it merely reports on the results of the TDM quantitative analysis, typically not including parts or extracts of the mined materials.²² It is worth highlighting, however, that contemporary research practices, striving for verifiability of research results, require the ability of researchers to store TDM source materials and to communicate them at least to their peers. From a legal perspective, this conduct could most likely trigger infringement of the right of communication to the public.

3. Can Existing Limitations be Applied to Text and Data Mining?

In EU law, exceptions and limitations are usually implemented by member states under a voluntary scheme, with very few exceptions provided as mandatory. The application of exceptions and limitations in EU law—and elsewhere—does occur according to the general principles set out in international law by the “three-step test.” According to this test, exceptions and limitations would be permitted (1) in certain special cases, (2) which do not conflict with a normal exploitation of the

17 Ibid., 31.

18 See Directive 1996/9/EC of the European Parliament and of the Council of 11 March 1996 on the Legal Protection of Databases, 1996 OJ (L 77) 20, Art. 5(a–b). See also Irini Stamatoudi, “Text and Data Mining,” in Irini Stamatoudi (ed.), *New Developments in EU and International Copyright Law* (Leiden: Kluwer Law International, 2016), 264–265.

19 See Directive 1996/9/EC, of the European Parliament and of the Council of 11 March 1996 on the Legal Protection of Databases, 1996 OJ (L 77) 20, Art. 5(b). Actually, although Directive 2001/29/EC does not harmonise the right to make adaptations and arrangements, its application has been claimed in EU law as an expression of the more general right of reproduction; see Maria Lillà Montagnani and Giorgio Aime, “Il text and data mining e il diritto d'autore,” *Annali Italiani di Diritto d'Autore* 26 (2018), fn. 15.

20 See Directive 1996/9/EC, of the European Parliament and of the Council of 11 March 1996 on the Legal Protection of Databases, 1996 OJ (L 77) 20, Art. 7.

21 Ibid., Arts 2(a), 7(1), and 7(2)(b). See also Court of Justice of the European Union, Case C-203/02, *British Horseracing Board Ltd and Others v. William Hill Organization Ltd*, 2004.

22 See Irini Stamatoudi (ed.), *New Developments in EU and International Copyright Law* (Leiden: Kluwer Law International, 2016), 262; and Maria Lillà Montagnani and Giorgio Aime, “Il text and data mining e il diritto d'autore,” *Annali Italiani di Diritto d'Autore* 26 (2018), fn. 20.

work or other subject matter, and (3) which do not unreasonably prejudice the legitimate interests of the rights-holder.²³ The three-step test has been increasingly interpreted in an expansive manner, especially in order to accommodate public interest.²⁴ A balanced approach to the implementation of the three-step test would especially support such application of exceptions and limitations to TDM to foster "public interest, notably in scientific progress ... and economic development."²⁵

In Europe, several exceptions within the mandatory and voluntary list provided by Directive 2001/29/EC have been selected as possible candidates to screen TDM from intellectual property infringement. Elsewhere, such as in the United States and Canada, opening clauses or fair use models have been deployed to the same effect.²⁶ Under current EU copyright law, TDM might be covered by exceptions and limitations available, but their application is uncertain.

3.1 Temporary Acts of Reproduction

The mandatory exception for temporary acts of reproduction might apply to limited TDM techniques.²⁷ Recital 10 of the DSM Draft Directive clarifies that this exception still applies, but its application would be limited to TDM techniques that involve only the making of temporary reproductions transient or incidental²⁸ to an integral and essential part of a technological process that enables a lawful use with no independent economic significance.²⁹

Doubts have been repeatedly cast on whether all these requirements are fulfilled by reproductions done for TDM purposes, especially where these reproductions are transient and have no independent economic relevance.³⁰ Application of temporary reproduction exception remains limited to residual cases for the large number of specific requirements that must be fulfilled, apparently in a cumulative

23 See Directive 2001/29/EC of the European Parliament and of the Council of 22 May 2001 on the Harmonisation of Certain Aspects of Copyright and Related Rights in the Information Society, 2000 OJ (L 167) 10–19, Art. 5(5).

24 See Bernt Hugenholtz and Ruth Okediji, *Conceiving an International Instrument on Limitations and Exceptions to Copyright*, Legal Studies Research Paper No. 2012-43 (Amsterdam: Amsterdam Law School, 2012), 3; Christophe Geiger, Jonathan Griffiths, and Reto Hilty, "Towards a Balanced Interpretation of the 'Three-Step Test' in Copyright Law," *European Intellectual Property Review* 4 (2008): 489–496; Christophe Geiger, "Implementing an International Instrument for Interpreting Copyright Limitations and Exceptions," *International Review of Intellectual Property and Competition Law* 40.6 (2009): 627–642; and Christophe Geiger, Daniel Gervais, and Martin Senftleben, "The Three Step Test Revisited: How to Use the Test's Flexibility in National Copyright Law," *American University International Law Review* 29.3 (2014): 581.

25 See, most recently, Joao Pedro Quintais, "Rethinking Normal Exploitation: Enabling Online Limitations in EU Copyright Law," *AMI* 6 (2017): 197–205.

26 See, for example, Giancarlo Frosio, *COMMUNIA Final Report on the Digital Public Domain* (Brussels: European Commission, COMMUNIA Network, and NEXA Center, 2011), 65–68; *Authors Guild v. Google*, 804 F.3d 202 (2nd Cir. 2015); *Authors Guild v. HathiTrust*, 755 F.3d 87 (2nd Cir. 2014); *Baker v. Selden*, 101 U.S. 99, 104 (1880); and Michael Geist, "Fairness Found: How Canada Quietly Shifted from Fair Dealing to Fair Use," in Michael Geist (ed.), *The Copyright Pentology* (Ottawa: University of Ottawa Press, 2013), 157–186.

27 See Directive 2001/29/EC of the European Parliament and of the Council of 22 May 2001 on the Harmonisation of Certain Aspects of Copyright and Related Rights in the Information Society, 2000 OJ (L 167) 10–19, Art. 5(1). See also Carine Bernault, "Les nouvelles exceptions au droit d'auteur," *Juris art etc.* 47 (2017): 22.

28 See Court of Justice of the European Union, Case C-360-13 *Public Relations Consultants Association*, 2014, ECLI:EU:C:2014:1195, §§ 43 and 50.

29 See European Commission, Proposal for a Directive of the European Parliament and of the Council on Copyright in the Digital Single Market, COM(2016)593 final, 2016/0280, 14 September 2016, Recital 10.

30 See Court of Justice of the European Union, Case C-5/08, *Infopaq International A/S v. Danske Dagblades Forening*, 2009, ECLI:EU:C:2009:465, § 64. See also Court of Justice of the European Union, Case C-360/13, *Public Relations Consultants Association*, 2014, ECLI:EU:C:2014:1195, §§ 40 and 48.

manner according to the CJEU.³¹ Also, the CJEU has reaffirmed that, being an exception, Article 5(1) of Directive 2001/29/EC must be interpreted restrictively.³²

3.2 Research Exception

In some member states, depending on whether or not it is implemented, the research exception may cover some TDM-relevant acts infringing upon intellectual property rights.³³ However, the use of this exception is marred by legal uncertainty regarding its scope and application to TDM in different member states.³⁴ In any case, the existing EU law limits the national research exceptions to non-commercial purposes and to the "sole purpose of illustration for teaching or scientific research."³⁵ All TDM projects that do not qualify as scientific research and have a commercial purpose, both direct or indirect economic or commercial advance,³⁶ will be excluded from the outset from the application of the exception.

As per the copyright in a database, the same research exemption would also be available.³⁷ This scenario would refer to the case where a TDM process reproduces the whole or substantial parts of a database, thus possibly infringing copyright in its original arrangement. All limitations mentioned regarding the research exception in Directive 2001/29/EC would apply to this case, as well as the possibility of claiming an exemption from the obligation of citing the source.³⁸ A research exception is also provided for the sui generis database right.³⁹ This exception would apply to a lawful user of a database for extracting or reusing a substantial part of the database's contents for non-commercial scientific research purposes, as long as the source is indicated.⁴⁰ However, this exception has seen multiple and diverging national implementations that might have provided for additional requirements.

31 See Court of Justice of the European Union, C-302/10 *Infopaq International A/S v. Danske Dagblades Forening*, 2012, ECLI:EU:C:2012:16, § 26.

32 Court of Justice of the European Union, Case C-5/08, *Infopaq International A/S v. Danske Dagblades Forening*, 2009, ECLI:EU:C:2009:465, § 56.

33 See Directive 2001/29/EC of the European Parliament and of the Council of 22 May 2001 on the Harmonisation of Certain Aspects of Copyright and Related Rights in the Information Society, 2000 OJ (L 167) 10–19, Art. 5(3)(a). See also Carine Bernault, "Les nouvelles exceptions au droit d'auteur," *Juris art etc.* 47 (2017): 22.

34 Irini Stamatoudi (ed.), *New Developments in EU and International Copyright Law* (Leiden: Kluwer Law International, 2016), 272–273.

35 Directive 2001/29/EC of the European Parliament and of the Council of 22 May 2001 on the Harmonisation of Certain Aspects of Copyright and Related Rights in the Information Society, 2000 OJ (L 167) 10–19, Art. 5(3)(a).

36 Irini Stamatoudi (ed.), *New Developments in EU and International Copyright Law* (Leiden: Kluwer Law International, 2016), 273.

37 Directive 1996/9/EC of the European Parliament and of the Council of 11 March 1996 on the Legal Protection of Databases, 1996 OJ (L 77) 20, Art. 6(2)(b).

38 Irini Stamatoudi (ed.), *New Developments in EU and International Copyright Law* (Leiden: Kluwer Law International, 2016), 275.

39 Directive 1996/9/EC of the European Parliament and of the Council of 11 March 1996 on the Legal Protection of Databases, 1996 OJ (L 77) 20, Art. 9(b).

40 Ibid.

3.3 Private Use Exception

Article 5(2)b of Directive 2001/29/EC could also be claimed as an exception applying to reproductions done for TDM purposes.⁴¹ The private copy exception might potentially cover some uses by individual researchers,⁴² in particular in member states that do not have a research exemption, thus allowing reproductions done for research purposes. However, the wording of the exception poses multiple challenges to its application to TDM. First, no direct or indirect commercial uses will be covered, leaving out most TDM research, which even if done by research organisations can have at least an indirect commercial end. Second, researchers might have to face the argument that the use for TDM might not be private if the use is not strictly for their own purpose—for example, if the results are used by a collective group of researchers or by their institution. Again, the application of this exception implies fair remuneration to be given. This remuneration must be calculated on the basis of the criterion of the harm caused to rights-holders,⁴³ which would need to be demonstrated in the context of TDM. Finally, the exception is implemented voluntarily by member states, thus exposing researchers to inconsistent national implementation, limited legal certainty, and high transaction costs.

3.4 Normal Use of a Database

A potential candidate for serving as a limitation for TDM is the so-called “normal use of a database.”⁴⁴ This provides that a lawful user can perform any reproductions of the database without additional authorization from the rights-holder, if those reproductions are necessary for accessing the contents of a database and making normal use of them.⁴⁵ Application of this limitation to TDM would be possible only as long as the mining constitutes normal use of the database. In the absence of a super-national uniform interpretation, the notion of “normal use” might receive multiple interpretations according to the member states in which it is applied, therefore limiting researchers’ legal certainty.

3.5 Extraction of Insubstantial Parts of a Database

The right of the lawful user to extract or reuse without the authorization of the rights-holder insubstantial parts from a database protected by sui generis right might also narrowly apply to TDM.⁴⁶ According to this provision, extraction or reuse might be done for any purpose whatsoever.⁴⁷ The notion of insubstantiality of a part must be evaluated through quantitative and qualitative criteria.⁴⁸ The CJEU has clarified that this assessment must consider the investment in the creation of

41 Directive 2001/29/EC of the European Parliament and of the Council of 22 May 2001 on the Harmonisation of Certain Aspects of Copyright and Related Rights in the Information Society, 2000 OJ (L 167) 10–19, Art. 5(2)b.

42 Christophe Caron, “République numérique rime avec exceptions et limitations au droit d’auteur,” *Communication Commerce Électronique* 11.89 (2016): 30.

43 Court of Justice of the European Union, Case C-467/08 *Padawan v. SGAE*, 2008, ECLI:EU:C:2010:620.

44 Reto M. Hilty and Heiko Richter, “Text and Data Mining,” in Reto M. Hilty and Valentina Moscon (eds), *Modernisation of the EU Copyright Rules* (Munich: Max Planck Institute for Innovation and Competition, 2017), 28–30.

45 Directive 1996/9/EC of the European Parliament and of the Council of 11 March 1996 on the Legal Protection of Databases, 1996 OJ (L 77) 20, Art. 6(1).

46 *Ibid.*, Art. 8(1).

47 *Ibid.*

48 *Ibid.*

the database and the prejudice that the extraction or reuse causes to that investment.⁴⁹ Put simply, harming the investment implies the infringement of the sui generis database right.⁵⁰ Apparently, if TDM does not harm that investment, and as such it should not, then Article 8(1) of Directive 1996/9/EC might serve to avoid liability for extractions from a database for TDM purposes. The repeated and systematic extraction of insubstantial parts would still be lawful as long as it does not reconstitute the whole or substantial parts of the database, therefore damaging the investment of the rights-holder.⁵¹ Again, however, the reach of this provision will be limited as it applies only to lawful users, running TDM on databases, using specific TDM techniques crawling the database rather than making a copy of it, and can be contractually overridden.⁵²

In sum, existing exceptions and limitations might not offer a stable legal framework to engage in TDM research projects safely and invest considerable resources. In addition, the voluntary implementation of most of these exceptions makes it even less predictable whether existing exceptions and limitations can be applied to TDM projects, especially those of a cross-border nature.

4. Text and Data Mining in the DSM Draft Directive Proposal: Is It Enough?

TDM limitations have long been under consideration in Europe.⁵³ In May 2015, the European Commission issued its Digital Single Market Strategy, in which it plans to provide "greater legal certainty for the cross-border use of content for specific purposes (e.g. research, education, text and data mining, etc.) through harmonised exceptions."⁵⁴ Following up on this plan, the DSM Draft Directive provides a TDM mandatory exception to the right of reproduction of copyright-protected subject matters and the sui generis database extraction right.⁵⁵ In addition, the TDM exception would apply to the new right over digital uses of press publication that the DSM Draft Directive has proposed.⁵⁶

49 Court of Justice of the European Union, Case C-203/02, *British Horseracing Board Ltd and Others v. William Hill Organization Ltd*, 2004, § 73.

50 See Irini Stamatoudi (ed.), *New Developments in EU and International Copyright Law* (Leiden: Kluwer Law International, 2016), 279; and Estelle Derclaye, "The Database Directive," in Irini Stamatoudi and Paul Torremans (eds), *EU Copyright Law* (Cheltenham, UK: Edward Elgar, 2014), 111.

51 See CJEU, Case C-203/02, *British Horseracing Board Ltd and Others v. William Hill Organization Ltd*, 2004, § 73.

52 Cf. Irini Stamatoudi (ed.), *New Developments in EU and International Copyright Law* (Leiden: Kluwer Law International, 2016), 280.

53 See, for example, Thomas Margoni and Giulia Dore, "Why We Need a Text and Data Mining Exception (But It Is Not Enough)," 2016, <https://zenodo.org/record/248048#.WXdf2oiGNEY>; and Christian Handke, Lucie Guibault, and Joan-Josep Vallbé, "Is Europe Falling Behind in Data Mining? Copyright's Impact on Data Mining in Academic Research," in Brigit Schmidt and Milena Dobrev (eds), *New Avenues for Electronic Publishing in the Age of Infinite Collections and Citizen Science: Scale, Openness and Trust* (Amsterdam: IOS Press, 2015), 120–130.

54 European Commission, Communication to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, A Digital Single Market Strategy for Europe, COM(2015)192 final, 6 May 2015, § 2.4.

55 European Commission, Proposal for a Directive of the European Parliament and of the Council on Copyright in the Digital Single Market, COM(2016)593 final, 2016/0280, 14 September 2016, Art. 3(1).

56 Ibid., Art. 11(1).

Several limitations would apply to the TDM exception. First, beneficiaries of TDM exceptions are limited to research organisations, meaning “any organisation the primary goal of which is to conduct scientific research or to conduct scientific research and provide educational services.”⁵⁷ Second, the exception allows only purpose-specific lawful access for TDM, namely “for the purpose of scientific research.”⁵⁸ Third, the exception applies only to works or other subject matter to which research organisations “have lawful access.” A further limitation is provided by Article 3(3) and Recital 12 allowing rights-holders to introduce measures to protect the “security and integrity” of their networks and databases where works are hosted; however, such measures shall not go beyond what is necessary to achieve that objective.⁵⁹

Within these important limitations, the TDM exception endorses a broad scope that includes both commercial and non-commercial uses, given that no exclusion of commercial uses is provided in the proposal.⁶⁰ In addition—and very importantly—the exception cannot be overridden by contract.⁶¹ Also, according to Article 6 of the DSM Draft Directive, the three-step test would apply to the new TDM exceptions. Finally, anti-circumvention provisions of technological protection measures would also apply to all new exceptions.⁶²

4.1 Reform Assessment: What Are the Benefits?

The introduction of Article 3 of the DSM Draft Directive meets important policy goals. In particular, it is set to provide a normalised level playing field for researchers across Europe to legally carry out TDM projects. The major positive impacts of the proposal lie in its focus on harmonisation of member states’ laws, through a mandatory solution. In particular, the inconsistency of existing TDM exceptions so far adopted by member states illustrates how fragmented the legal landscape will rapidly become if no EU-wide action is undertaken.⁶³

In addition, voluntary implementation of exceptions and limitations at the national level can be rated highly among the critical issues for researchers in performing TDM research in Europe. Indeed, the voluntary nature of the exceptions that might apply to TDM further affects cross-border collaborations, as researchers would be unaware—or face high transaction costs for clearance—of whether TDM would be lawful across all EU jurisdictions involved in the research collaboration and according to which standards. A recent CEIPI study listed exceptions and limitations to copyright as

57 Ibid., Art. 2(1).

58 Ibid., Art. 3(1).

59 Ibid., Art. 3(3).

60 See also European Commission, Proposal for a Directive of the European Parliament and of the Council on Copyright in the Digital Single Market, COM(2016)593 final, 2016/0280, 14 September 2016, 8, noting that “Option 3 allowed uses for commercial scientific research purpose but limited the benefit of the exception to some beneficiaries. Option 4 went further as it did not restrict beneficiaries. Option 3 was deemed to be the most proportionate one.”

61 European Commission, Proposal for a Directive of the European Parliament and of the Council on Copyright in the Digital Single Market, COM(2016)593 final, 2016/0280, 14 September 2016, Art. 3(2).

62 Ibid., Art. 6.

63 See, for example, Copyright, Designs and Patents Act 1988, § 29A (United Kingdom); Art. 38 of the Law No. 2016-1231 for a Digital Republic added paragraph 10 to Art. L122-5 and paragraph 5 to Art. L342-3 of the Intellectual Property Code (*Code de la propriété intellectuelle*) (France); Estonian Copyright Act, Art. 19(3); and German Copyright Act, Art. 60d. See also Copyright Act, Sec. 5, Art. 47-7 (Japan).

one of the areas of major divergence in national copyright law.⁶⁴ From this follows “the importance of declaring that limitations and exceptions justified by the public interest be mandatory.”⁶⁵ This conclusion applies here with specific emphasis to the TDM exception, but the mandatory nature should be extended to all limitations and exceptions of the EU *acquis* in order to achieve true harmonisation.⁶⁶ A unified and mandatory approach is especially crucial in the “digital environment as the internet involves uses that, most of the time, affect several copyright legislations, leading to major insecurity regarding what is allowed.”⁶⁷ In this respect, a TDM exception should serve to bridge the gap with other jurisdictions, such as the United States, where apparently TDM would be beyond the reach of copyright-holders’ exclusive rights.⁶⁸

Again, harmonisation will be supported by an expansive scope of the limitation, covering both commercial and non-commercial uses, and the unenforceability of contrary contractual provisions.⁶⁹ This inclusion would be critical in order not to void the exception of any practical utility. As mentioned, publishers can contractually rule out mining in their licences, and transaction costs to obtain permission to mine content from multiple publishers might *de facto* make TDM projects unsustainable. Certainly, the proposal deserves praise for protecting TDM research from contractual enclosure.

4.2 Reform Assessment: What are the Shortcomings?

There still remain negative impacts of the proposal as currently drafted that need to be assessed. They range from the scope of the exception that is constrained by multiple limitations to the coexistence of the exception with technological protection measures.

4.2.1 Limited Scope: Research Organizations

Much discussion regarding this proposal concerns whether the TDM exception’s beneficiaries should not be limited to “research organisations.” To qualify for the exception, research organisations must operate on a not-for-profit basis or by reinvesting all the profits in their scientific research,

64 Christophe Geiger and Franciska Schönherr, *Frequently Asked Questions (FAQ) of Consumers in Relation to Copyright, Summary Report* (Alicante: European Union Intellectual Property Office, 2017), 6–8, <https://euipo.europa.eu/ohimportal/web/observatory/observatory-publications>.

65 Stéphanie Carre, Christophe Geiger, Jean Lapousterle, Franck Macrez, Adrien Bouvel, Théo Hassler, et al., *Response of the CEIPI to the Public Consultation of the European Commission on the Review of the European Union Copyright Rules*, CEIPI Research Paper No. 2014-01 (Strasbourg: Center for International Intellectual Property Studies, 2014), 6, ssrn.com/abstract=2971029.

66 Cf. Christophe Geiger and Franciska Schönherr, “Limitations to Copyright in the Digital Age,” in Andrej Savin and Jan Trzaskowski (eds), *Research Handbook on EU Internet Law* (Cheltenham, UK: Edward Elgar, 2014), 127.

67 Christophe Geiger, Oleksandr Bulayenko, Théo Hassler, Elena Izyumenko, Franciska Schönherr, and Xavier Seuba, *Reaction of CEIPI to the Resolution on the Implementation of Directive 2001/29/EC on the Harmonisation of Copyright in the Information Society Adopted by the European Parliament on the 9th July 2015*, CEIPI Research Paper No. 2015-01 (Strasbourg: Center for International Intellectual Property Studies, 2015), 17, ssrn.com/papers=2970507.

68 *Ibid.*, 24. See also European Commission, *Standardisation in the Area of Innovation and Technological Development, Notably in the Field of Text and Data Mining: Report from the Expert Group* (Brussels: European Commission, 2014), 3, 7, 12–13, 43, and 65.

69 Provisions protecting some exceptions from contractual override are already present in Directive 1996/9/EC of the European Parliament and of the Council of 11 March 1996 on the Legal Protection of Databases, 1996 OJ (L 77) 20, Arts 6(1) and 15; and in the Directive 2009/24/EC of the European Parliament and of the Council of 23 April 2009 on the Legal Protection of Computer Programs, 2009 OJ (L 111) 16–22, Arts 5(2) and 8.

or pursuant to a public interest mission.⁷⁰ According to Recital 11, a public interest mission might be “reflected through public funding or through provisions in national laws or public contracts.”⁷¹ The DSM Draft Directive further limits the scope of the exception that does not apply to research institutions controlled by commercial undertakings.⁷²

From a broader and more fundamental perspective, limiting beneficiaries would undermine a widespread assumption that the “right to read should be the right to mine.”⁷³ From a practical market-based perspective, this policy choice might cripple opportunities for start-ups and individual researchers in this area.⁷⁴ Indeed, the policy choice of excluding from the reach of the exception unaffiliated individuals and researchers—operating under the same terms as those organised in a qualifying research organisation—might fall short in terms of adequacy and proportionality. Actually, the existing United Kingdom exception for text and data analysis includes also individual researchers as beneficiaries and any person with lawful access to a work.⁷⁵

Also, it is worth noting that the narrow application of the limitation to research organisation does not fully provide the European DSM with the legal framework to fill the gap with other jurisdictions adopting opening clauses or fair use models to allow a broader number of research players to perform TDM research and promote related innovation. Given the global nature of the modern economy, the impact assessment should have examined the impact of the proposed exception on the EU’s competitive advantage against other top innovative economies enabling all undertakings to carry out TDM under fair use/fair dealing models (e.g. United States, Canada, Israel).⁷⁶

4.2.2 Limited Scope: Scientific Research Purposes

Limiting the TDM exception to “scientific research” only might curtail the efficacy of the reform and create practical complications. The impact assessment does not provide any rationale for making lawful access purpose-specific. This approach disregards a large number of possible applications of

70 European Commission, Proposal for a Directive of the European Parliament and of the Council on Copyright in the Digital Single Market, COM(2016)593 final, 2016/0280, 14 September 2016, Art. 2(1)(a–b).

71 Ibid., Recital 11.

72 Ibid., Art. 2(1).

73 Peter Murray-Rust, Jennifer Molloy, and Diane Cabell, “Open Content Mining,” in Samuel A. Moore (ed.), *Issues in Open Research Data* (London: Ubiquity Press, 2014), 28.

74 See, for example, the Conference of European Schools for Advanced Engineering Education and Research, the European University Association, the League of European Research Universities, and the Association of European Research Libraries, “Future-proofing European Research Excellence: A Statement from European Research Organisations on Copyright in the Digital Single Market,” 10 January 2017, 1–2, <https://www.leru.org/publications/future-proofing-european-research-excellence>. For a criticism, see Benjamin Raue, “Free Flow of Data? The Friction Between the Commission’s European Data Economy Initiative and the Proposed Directive on Copyright in the Digital Single Market,” *International Review of Intellectual Property and Competition Law* 379 (2018): 382; and Thomas Margoni and Martin Kretschmer, *The Text and Data Mining Exception in the Proposal for a Directive on Copyright in the Digital Single Market: Why It Is not What EU Copyright Law Needs*, 25 April 2018, <https://www.create.ac.uk/blog/2018/04/25/why-tdm-exception-copyright-directive-digital-single-market-not-what-eu-copyright-needs> stating that “a commercial enterprise will not be able to benefit from the exception. Nor a University acting for any other purpose than research (e.g. commercial). Other purposes commonly accepted as fundamental in democratic societies are also excluded, such as journalism, criticisms or review.”

75 See Copyright, Designs and Patents Act 1988, § 29A (United Kingdom).

76 See Christophe Geiger, Oleksandr Bulayenko, Théo Hassler, Elena Izyumenko, Franciska Schönherr, and Xavier Seuba, *Reaction of CEIPI to the Resolution on the Implementation of Directive 2001/29/EC on the Harmonisation of Copyright in the Information Society Adopted by the European Parliament on the 9th July 2015*, CEIPI Research Paper No. 2015-01 (Strasbourg: Center for International Intellectual Property Studies, 2015), 24, ssrn.com/papers=2970507.

TDM that might now be construed—being excluded from the reach of the exception—as within the exclusive rights of the copyright-holders.

Moreover, this purpose-specific approach might raise subtle issues of applicability of the new limitation within research organisations enjoying lawful access to a database. For example, if a public university has lawful access to a database under a “for educational purpose” licence, would it need to pay an additional licensing fee for a “scientific research” purpose? If this is the case, then would this obligation contradict the prohibition of contractually overriding the TDM exception?⁷⁷ Given the scope of the new limitation—and the “no-contractual-override” provision—the answer is probably not. Still, research institutions might find these possible legal uncertainties a limitation to the deployment of TDM research due to the potential liability that might arise and related transaction costs that should be considered before running TDM research projects. Since the exception is already limited to research organisations, dropping restrictions to purpose-specific uses of lawfully accessed databases might avoid unwanted results.

4.2.3 Limited Scope: Lawful Access

Applying the exception only to works to which the research organisations have “lawful access” would de facto subject TDM research to private ordering.⁷⁸ According to the European Copyright Society, “the exception can effectively be denied to certain users by a rights-holder who refuses to grant ‘lawful access’ to works or who grants such access on a conditional basis only.”⁷⁹

In addition, subjecting TDM to lawful access will make TDM research projects harder to run by raising related costs. Possibly, publishers might price TDM into their subscription fees if only those with lawful access can perform TDM research. Subjecting TDM research to market access discriminates research according to research organisations’ market power. Only a few research organisations will be able to acquire licences for all databases that are relevant for a TDM research project.⁸⁰ This will make comprehensive TDM projects impossible to perform for the majority of research organisations, especially those from the member states with more limited access to funding. In turn, this will widen the gap between richer and poorer research institutions and, most likely, increase the scientific and innovation divide between developed and less developed European countries.

4.2.4 Coexistence with Technological Protection Measures

The introduction of measures to protect the security and integrity of networks and databases might allow rights-holders to block access for researchers trying to conduct TDM.⁸¹ However, Recital 12 spells out clearly that “those measures should not exceed what is necessary to pursue the objective of

77 See European Commission, Proposal for a Directive of the European Parliament and of the Council on Copyright in the Digital Single Market, COM(2016)593 final, 2016/0280, 14 September 2016, Art. 3(2).

78 But see European Commission, *Standardisation in the Area of Innovation and Technological Development, Notably in the Field of Text and Data Mining: Report from the Expert Group* (Brussels: European Commission, 2014), 55 and 58, justifying the “lawful access” requirement as shielding private actors from an obligation to open up their data to third parties.

79 European Copyright Society, *General Opinion on the EU Copyright Reform Package* (European Copyright Society, 2017), 4.

80 Ibid.

81 See the Conference of European Schools for Advanced Engineering Education and Research, the European University Association, the League of European Research Universities, and the Association of European Research Libraries, “Future-proofing European Research Excellence: A Statement from European Research Organisations on Copyright in the Digital Single Market,” 10 January 2017, 2, <https://www.leru.org/publications/future-proofing-european-research-excellence>.

ensuring the security and integrity of the system and should not undermine the effective application of the exception."⁸² For the avoidance of doubt, the same wording should be included in Article 3(3) also, rather than referring only to a limitation to measures exceeding their objective.

It is worth noting that the application of anti-circumvention provisions might trample over users' privileged uses. The effects of technological protection measures on exceptions and limitations have been highlighted by abundant literature.⁸³ Technological protection measures might limit or prevent access to works altogether for purposes that are not restricted by authors' rights or for uses that are actually privileged. Rights-holders' obligations to make available the means to benefit from exception and limitations do not themselves limit liability for circumvention.⁸⁴ Also, inconsistent implementations across national jurisdictions of measures to guarantee the application of exceptions and limitations against technological protection measures' anti-circumvention provisions might effectively curtail harmonised enjoyment of the new mandatory exceptions, thus limiting DSM effectiveness.

4.3 Reform Assessment: Is There Room for Improvement?

Specific ameliorations of the TDM limitations currently drafted should be considered carefully.

First, some definitional clarifications would be needed: (1) for the avoidance of doubt, Recital 8 of the Draft Directive should mention that also works and other subject matter not protected by copyright or neighbouring rights can be freely mined. (2) The proposed reform does not define the notion of "lawful access."⁸⁵ However, the existing exception Article 5(1) of Directive 2001/29/EC that might cover some TDM techniques involving temporary reproduction refers to "lawful use," which has been defined by the Directive and unambiguously interpreted by the CJEU.⁸⁶ If "lawful access" is intended to mean what "lawful use" means, then the reform should maintain the term already adopted in EU law in a provision already covering some TDM techniques. (3) The notion of "normal use" of a database might receive multiple interpretations according to the member states in which it is applied. Therefore, harmonisation should be pursued by including TDM in the EU law notion of "normal use."

82 European Commission, Proposal for a Directive of the European Parliament and of the Council on Copyright in the Digital Single Market, COM(2016)593 final, 2016/0280, 14 September 2016, Recital 12.

83 See, for example, Giancarlo Frosio, *COMMUNIA Final Report on the Digital Public Domain* (Brussels: European Commission, COMMUNIA Network, and NEXA Center, 2011), 99–103 and 135–141.

84 See Directive 2001/29/EC of the European Parliament and of the Council of 22 May 2001 on the Harmonisation of Certain Aspects of Copyright and Related Rights in the Information Society, 2000 OJ (L 167) 10–19, Art. 6(4).

85 See European Commission, Proposal for a Directive of the European Parliament and of the Council on Copyright in the Digital Single Market, COM(2016)593 final, 2016/0280, 14 September 2016, Recital 9 and Art. 3(1).

86 See Directive 2001/29/EC of the European Parliament and of the Council of 22 May 2001 on the Harmonisation of Certain Aspects of Copyright and Related Rights in the Information Society, 2000 OJ (L 167) 10–19, Recital 33 (noting that "[a] use should be considered lawful where it is authorised by the rightholder or not restricted by law"). See also Court of Justice of the European Union, Cases C-403/08 and C-429/08, *Football Association Premier League and Others*, 2011, ECLI:EU:C:2011:631, § 168; and Court of Justice of the European Union, Case C-302/10, *Order, Infopaq International*, 2012, ECLI:EU:C:2012:16, § 42.

Second, the scope of the exception should be expanded:⁸⁷ (1) the TDM exception should not be limited to research organisations but should be extended to all those enjoying lawful access to underlying mined materials—as the right to read should be the right to mine—especially in order not to cripple research from start-ups and independent researchers. (2) In any event, the possibility of extending the exception to some other defined categories of beneficiaries, such as journalists, should at least be assessed. (3) In case of TDM for commercial uses carried out by some entities (e.g. other than research organisations or individual researchers, public authorities, and journalists), fair remuneration could be considered, provided that harm can be demonstrated on the basis of relevant empirical data. (4) Since the exception is already limited to research organisations, dropping restrictions to purpose-specific uses of lawfully accessed databases might avoid unwanted results. (5) In light of the increasing research focus on quality and verifiability, a TDM exception should enable storing and communication of research files created for TDM.

Third, as technological enclosure might cripple TDM research, the proposal should make clear that the exception would also be protected from override by technological protection measures. In this regard, the same wording included in Recital 12 of the DSM Draft Directive should also be included in Article 3(3) by stating plainly that security and integrity measures should not “undermine the effective application of the exception,” rather than referring only to a limitation to measures exceeding their objective. In addition, a provision limiting contractual and technological override should be extended to any exceptions potentially covering TDM, including for example the TDM techniques covered by Article 5(1), Directive 2001/29/EC. Finally, protection against contractual and technological override should also always be extended to TDM of materials not protected by IPRs, including those made available in a database.

5. Conclusions

While artificial intelligence might be set to become the most disruptive technology in the years to come, it does bring about a set of thorny legal challenges. In particular, neural network and machine learning technologies have been growing at an unimaginable pace thanks to the availability of big data streams in the internet and other digital networks. These artificial intelligence learning processes must use inputs possibly protected by IPRs to create wholly transformative outputs. TDM has been a fundamental technique to make machine learning possible by copying or crawling massive datasets and empowering artificial intelligence autonomous decision-making and creativity.

87 Several scholars have argued for such an expansion of the scope of the limitation. See, for example, with further references, Nicolas Jondet, “L’exception pour le data mining dans le projet de directive sur le droit d’auteur: pourquoi l’Union européenne doit aller plus loin que les législations des Etats membres,” *Propriétés intellectuelles* 67 (2018), in particular pp. 33–34. Interestingly, in the latest proposal by the Presidency of the Council of the EU, 17 May 2018, Interinstitutional File 2016/0280 (COD), an optional limitation, additional to the one on TDM by research organizations, has been introduced with the following drafting: “Article 3a, Optional exception or limitation for text and data mining ... 1. Without prejudice to Article 3 of this Directive Member States may provide for an exception or a limitation to the rights provided for in Article 2 of Directive 2001/29/EC, Articles 5(a) and 7(1) of Directive 96/9/EC and Article 11(1) of this Directive for temporary reproductions and extractions of lawfully accessible works and other subject-matter that form a part of the process of text and data mining. 2. The exception or limitation provided for in paragraph 1 shall apply provided that the use of works and other subject matter referred to therein has not been expressly reserved by their rightholders including by technical means.” If this is a positive move, then the optional character of the limitation will create disparities in the digital single market with regard to TDM activities. Moreover, it conditions the effectivity of the exception to the goodwill of rights-holders, thus weakening its potential applications.

The EU has been struggling for some time over whether TDM techniques should be considered within the reach of copyright and other sui generis rights or whether they should be exempted from that reach. In order to bring clarity in a confused panorama of possible applicable exceptions and limitations to TDM activities, the DSM Directive Proposal would like to introduce a specific exception. The new exception will facilitate research and innovation in the DSM by bringing about long-sought harmonisation. Its narrow scope, however, will limit these substantive positive externalities to a comparatively small number of research institutions, while the DSM at large will still lag behind other jurisdictions, allowing a larger cluster of market players to engage legally in TDM activities. This might result in a critical weakness for the DSM while racing to reach a dominant position in the market for artificial intelligence technology. Being unable to make full use of the immense riches made available by big data streams in digital networks for artificial intelligence, machine learning, and neural network applications will put Europe in a disadvantaged position from which it might be hard to recover in the future.

To the end of exploring all solutions that could boost EU technological innovation and competitiveness against other jurisdictions, this reform should be an opportunity to reflect on the future design of an "opening clause" to be added to the list of exempted uses. The introduction of an open norm—or general exception—similar to US fair use has long been considered in EU legal scholarship and policy debate.⁸⁸ An "opening clause" should address uses that are not yet covered by existing exceptions and limitations but are justified by important public interest rationales and fundamental rights, such as freedom of expression and the right to information. In this regard, CEIPI, for example, has already endorsed a policy option that would guarantee legal certainty through a list of further harmonised or unified exceptions and limitations, but combining it with a certain dose of flexibility, in order to ensure the EU legal framework's capacity to adapt to a rapidly changing environment. This limited "opening" of the list of exceptions and limitations could possibly be based on the three-step test.⁸⁹

Among endless applications, an opening clause would make TDM research possible according to the three-step test and the impact of the use on the legitimate interest of the users, being limited by any prejudice on the potential market of the rights-holder, if any exists. In light of a balanced approach to the three-step test, an opening clause might allow rights-holders fair compensation if any prejudice

88 See European Commission, *Standardisation in the Area of Innovation and Technological Development, Notably in the Field of Text and Data Mining: Report from the Expert Group* (Brussels: European Commission, 2014), 57; Martin Senftleben, "The Perfect Match: Civil Law Judges and Open-Ended Fair Use Provisions," *American University International Law Review*, 33 (2017): 231–286; P. Bernt Hugenholtz, "Flexible Copyright: Can EU Authors' Rights Accommodate Fair Use?" in Irini Stamatoudi (ed.), *New Developments in EU and International Copyright Law* (Leiden: Kluwer Law International, 2016), 417–433; Martin Senftleben, "Comparative Approaches to Fair Use: An Important Impulse for Reforms in EU Copyright Law," in Graeme Dinwoodie (ed.), *Methods and Perspectives in Intellectual Property* (Cheltenham, UK: Edward Elgar, 2014); Antony Dnes, "Should the UK Move to a Fair-Use Copyright Exception," *International Review of Intellectual Property and Competition Law* 44.4 (2013): 418–444; Rob Van der Noll, Stef van Gompel, Lucie Guibault, Jarst Weda, Joost Poort, Ilan Akker, and Kelly Breemen, *Flexible Copyright: The Law and Economics of Introducing an Open Norm in the Netherlands* (Amsterdam: SEO Amsterdam Economics, 2012); and Christophe Geiger, "Flexibilising Copyright: Remedies to the Privatisation of Information by Copyright Law," *International Review of Intellectual Property and Competition Law* 39.2 (2008): 178–197.

89 See Christophe Geiger, Oleksandr Bulayenko, Théo Hassler, Elena Izyumenko, Franciska Schönherr, and Xavier Seuba, *Reaction of CEIPI to the Resolution on the Implementation of Directive 2001/29/EC on the Harmonisation of Copyright in the Information Society Adopted by the European Parliament on the 9th July 2015*, CEIPI Research Paper No. 2015-01 (Strasbourg: Center for International Intellectual Property Studies, 2015), 20–21, ssrn.com/papers=2970507; and Christophe Geiger, "Copyright as an Access Right, Securing Cultural Participation through the Protection of Creators' Interests," in Rebecca Giblin and Kimberlee G. Weatherall (eds), *What if We Could Reimagine Copyright?* (Acton: Australian National University Press, 2016), 73.

to rights-holders' interest or conflict with the normal exploitation of the work might occur. In this regard, TDM research and innovation would profit substantially from such an opening clause. It would, on the one hand, close loopholes for TDM activities that do not affect rights-holders' investments or market returns. On the other hand, it would provide European researchers and businesses with a level playing field to compete with researchers and businesses from other jurisdictions.

Inventive Machines: Rethinking Invention and Patentability

Ryan Abbott

Computers are doing more than ever before.¹ They are doing it cheaper, faster, and often better than their human counterparts, and on an unprecedented scale. Take, for example, Amazon's Kiva robots, which help retrieve and package items. Amazon now has 45,000 of these robots working together with 230,000 human employees. I suspect it will not be long until there are 230,000 next-generation Kiva robots working together with 45,000 human employees. Or, perhaps, 5,000 next-generation robots and no human employees.

Robots are doing more than manual labour—they are working as doctors, lawyers, and scientists. They are also getting pretty good at playing games. IBM's supercomputer Deep Blue beat world chess champion Garry Kasparov in 1997, IBM's next-generation supercomputer Watson won a game of Jeopardy! in 2011, and last year Google's supercomputer DeepMind's AlphaGo program beat a master Go player, Lee Se-dol. Of course, playing games is just a way for these computers to demonstrate their capabilities. Watson, for instance, is now developing cancer treatment protocols for patients at Memorial Sloan Kettering Center. IBM also has Watson developing new food recipes and doing some tremendous things involving a food truck.

You can now go to IBM's website and work with Chef Watson to create new recipes. Watson is less restricted by preconceptions about combining foods and flavours than human chefs. That allows Watson to generate recipes that people have not really thought about before. Put another way, Watson is coming up with new, inventive, and industrially applicable compositions. For those of us in patent law, that raises the question of whether Watson's ideas are patentable, and if so, who would qualify as an inventor for such patents?

It has been at least 20 years since the first autonomous machine invention was patented. The first such invention I am aware of was created by the "Creativity Machine," which used a neural network architecture. It essentially consisted of a series of networked on-and-off switches connected in a neural network, which generated new output when perturbed. The first network was connected to a second network, which evaluated the output for usefulness. The Creativity Machine was given a goal

1 This article, and the associated presentation, is based on the author's research on computer generated works. See, for example, Ryan Abbott, "Hal the Inventor: Big Data and Its Use by Artificial Intelligence," in Cassidy R. Sugimoto, et al. (eds), *Big Data Is Not a Monolith* (Cambridge, MA: MIT Press 2016); Ryan Abbott, "I Think, Therefore I Invent: Creative Computers and the Future of Patent Law," *Boston College Law Review* 57.4 (2016); Ryan Abbott, "Artificial Intelligence, Big Data and Intellectual Property: Protecting Computer-Generated Works in the United Kingdom," in Tanya Aplin (ed.), *Research Handbook on Intellectual Property and Digital Technologies* (Cheltenham, UK: Edward Elgar, forthcoming); Ryan Abbott, "Everything is Obvious," 66 *UCLA Law Review*, forthcoming. These works are all available at <http://ssrn.com/author=1702576>. Readers interested in this subject may also be interested in early works by Pamela Samuelson, Arthur Miller, and Ralph Clifford, "Allocating Ownership Rights in Computer-Generated Works," *University of Pittsburgh Law Review* 1185 (1986); 1199–1200; Arthur R. Miller, "Copyright Protection for Computer Programs, Databases, and Computer-Generated Works: Is Anything New Since CONTU?" *Harvard Law Review* 106 (1993): 1043; and Ralph D. Clifford, "Intellectual Property in the Era of the Creative Computer Program: Will the True Creator Please Stand Up?" *Tulane Law Review* 71 (1997): 1675–1703. A most incomplete list of more recent scholarship includes: Lisa Vertinsky and Todd M. Rice, "Thinking about Thinking Machines: Implications of Machine Inventors for Law," *Boston University Journal of Science and Technology Law* 8.2 (2002); Robert Plotkin, *The Genie in the Machine* (Redwood City, CA: Stanford University Press, 2009); C.R. Davies, "An Evolutionary Step in Intellectual Property Rights: Artificial Intelligence and Intellectual Property," *Computer Law and Security Review*, 27.6 (2011); Annemarie Bridy, "Coding Creativity: Copyright and the Artificially Intelligent Author," *Stanford Technology Law Review* 5 (2012); J. McCutcheon, "Curing the Authorless Void: Protecting Computer-Generated Works Following ICETV and Phone Directories," *Melbourne University Law Review*, 37.1 (2013); Ben Hattenbach and Joshua Glucoft, "Patents in an Era of Infinite Monkeys and Artificial Intelligence," *Stanford Technology Law Review* 19 (2015); Jean-Marc Deltorn, "Deep Creations: Intellectual Property and the Automata," *Frontiers in Digital Humanities*, 2017, <https://www.frontiersin.org/articles/10.3389/fdigh.2017.00003/full>; Shlomit Yanisky-Ravid and Xiaoqiong Liu, "When Artificial Intelligence Systems Produce Inventions: the 3A Era and an Alternative Model for Patent Law," *Cardozo Law Review*, forthcoming; and W. Michael Schuster, "A Coasean Analysis of Ownership of Patents for Inventions Created by Artificial Intelligence," *Washington and Lee Law Review*, forthcoming.

to complete, and from that it independently produced a result. A process like this could be used in a variety of industries to, say, discover a new polymer or to design a faster semiconductor.

The Creativity Machine, if it were a human being, would be an inventor in these circumstances. Inventorship does not go to the person who instructs someone else to solve a problem. If I tell my research scientist that I would like her to design a better battery and she does, that does not make me an inventor of her battery. The research scientist would be the inventor. In the case of the Creativity Machine, the United States Patent and Trademark Office (USPTO) granted a patent for the machine's invention, but did so in the name of the machine's owner. That was an easy decision for the Patent Office as the application had not disclosed the machine's involvement.

The Creativity Machine may have been the first autonomous machine inventor, but it certainly was not the last. More patents were created autonomously by machines in the 2000s—for example, by the "Invention Machine," which relied on genetic programming. Inventions autonomously created by the Invention Machine were also issued patents by the USPTO, again under circumstances in which, if the machine had been a person, the machine would have been the inventor.

Of course, right now there may be few machines independently inventing. Most machines are involved in the inventive process as simple tools that help people to "reduce to practice" an invention. If I design an experiment and have my PhD students carry it out without change, and the experiment's results are patentable, I, and not my students, am probably the inventor for those results. Similarly, most computers are just executing tasks given by people. But at least some of the time, the computer occupies the role of the inventor. I suspect you are not hearing more about autonomous machine inventions because of concerns about patentability. Can a machine be an inventor? Should a machine be an inventor? These are open questions, and they are important theoretical and practical questions because computers are *de facto* inventing, and inventors have ownership rights in patents. Failure to list inventors can make patents invalid or unenforceable.

I have looked at this primarily from a US law perspective and found no statute that discusses computer inventorship, there is no case law directly on the issue, and there is no relevant patent office policy. However, there are some barriers to computer inventorship. For instance, the 1952 Patent Act uses the term "individual" to describe potential inventors, something that was done to prevent corporate inventorship. There is also quite a bit of judicial language characterising invention as a "mental act."

While there is no patent office policy on computational inventions or computer-generated works, there is a copyright office policy on computer authorship. That policy dates to 1984 and states that works "authored" by a computer cannot qualify for copyright protection. In England and Wales, the rule is different under the Copyright, Designs and Patents Act of 1988: if a work is computer-generated, the author is the person who makes the arrangements for the creation of the work.

The United States Copyright Office cites the 1886 case of *Burrow-Giles v. Sarony* in support of its current policy. In that case, a photographer, Napoleon Sarony, sued the Burrow-Giles Lithographic Company for copyright infringement of a famous photograph of Oscar Wilde. The company alleged that the photographer could not be the photograph's author because a photograph is just a mechanical reproduction of a natural phenomenon. The Court held that any form of writing by which a mental idea is given visible expression is eligible for copyright protection.

The case thus explicitly dealt with whether the use of a machine would negate human authorship, and implicitly with whether a camera could be considered an author. If it seems unwise to rely on dicta from the Gilded Age to formulate policies on machine authorship—well, that is what is happening. This policy was relevant to a recent case in the Ninth Circuit in California involving the famous “Monkey Selfies.” In that case, a crested macaque in Indonesia took pictures of itself using equipment belonging to a nature photographer, David Slater. Mr Slater promptly claimed copyright in the photographs. Eventually, the United States Copyright Office clarified that because only a person could be an author, that copyright could not subsist in the Monkey Selfies. People for the Ethical Treatment of Animals (PETA) sued Mr Slater in the United States Federal Court for copyright infringement on behalf of the macaque, alleging that the primate should be the copyright owner of its own photographs. The case ultimately settled, with Mr Slater agreeing to donate 25% of future revenue from his use of the photograph to charities dedicated to protecting crested macaques in Indonesia.

If we analogueise this copyright case law to the patent context, then maybe a computer cannot be an inventor and its discoveries enter in the public domain. Computers do not need incentives to invent, and permitting computer inventorship might chill human invention.

However, there is a way around computer involvement that works in the patent but not the copyright context. Inventorship can also be based on *recognition* of inventive subject matter. Thus, a person may be an inventor by virtue of recognising that a computer has invented something patentable. This is almost certainly how the problem is being dealt with today in practice—just as it was for the earliest computational inventions. It avoids having to disclose an inventive computer to the USPTO and potentially throwing a wrench into a patent application. For patent attorneys, there is no incentive right now to disclose inventive activity by computers, and plenty of incentive not to make that disclosure.

The system of invention by recognition seems reasonable if you are the first scientist to notice that penicillin is inhibiting bacterial growth, but perhaps not if you are taking the credit for the work of another inventive entity—even if that entity is a computer. In the latter case, the system is rewarding people even if they are not doing anything inventive themselves. A computer might clearly identify its own results as being patentable. For that matter, it might even format its results as a patent application. Claiming credit for the work of a machine also devalues human invention, because it equates the contributions of people using inventive machines and human inventors who have legitimately engaged in inventive activity.

Taking credit for a machine's work also has the potential to create logistical problems when the first person to notice a computer's results is not the computer's owner or the person who gave the computer a goal to complete. This may incentivise computer owners to restrict access to their machines so that they can control ownership of inventive output.

More ambitiously, I argue that we should recognise computers as inventors. This will functionally produce more invention because it will incentivise the development of creative computers. That is because allowing computer owners to patent the output of their machines makes those machines more valuable. The constitutional rational for granting patent inventions in the United States is based on an incentive theory. We want patents because of the free-rider problem and because

patents are thought to generate additional research and discovery. Even though computers do not care about incentives, people who design computers do. Acknowledging computers as inventors would reward effort upstream of the stage of invention, and it could also promote disclosure and commercialisation of patentable subject matter. It would also validate inventor moral rights, because it will distinguish between human inventors who contribute conceptually to an invention and persons filing applications based on the autonomous output of machines.

What about the potential barriers we discussed—that invention must be a mental act and that an inventor must be an individual? Well, there are computers that generate output in a process akin to a person's mental act—for instance, computers that utilise neural networks. There are also computers that generate output in totally different ways, like those that use expert-based systems. Should it matter how a computer is designed and how it functions?

I would argue no. We should care functionally about whether the system generates innovation, not how innovation occurs. Congress came to that same conclusion in 1952 when it abolished the “flash of genius” test. That was an old requirement that required that the inventive spark come to a person in an “aha” moment rather than as the result of methodical, laborious research. The nature of the test was never entirely clear; it involved judges subjectively reasoning about what an applicant might have been thinking. Congress eventually decided it was not a good test, and that we should not care about what goes on in someone's head, just whether what they create is inventive and beneficial for society.

Similarly, the requirement that individuals should be inventors should not interfere with computer inventorship. That language is from the 1950s—long before the issue of computational invention was relevant. It should be interpreted according to dynamic principles of statutory interpretation in light of the purpose of the original Act, which was to prevent corporate inventorship.

If a computer could be an inventor, who would own its patent? I am not arguing that a computer should own a patent. Computers are owned as property and do not have legal rights. I would argue that the computer's owner should be the automatic assignee of anything the computer develops. Where multiple parties are involved, such as software developers, computer owners, and users, they could work out issues of ownership by contract, starting with the default position that the computer owner is the assignee. This would be the most consistent with the way we treat personal and intellectual property right now.

Computational invention has exciting implications beyond inventorship. I think creative computers are going to change the entire patent paradigm in the next 10–20 years.

Even more interesting than thinking about how computers and people are competing right now in inventive activity is that computers are very soon going to overwhelm people in inventive activity. Take biotechnology research on antibodies as an example. There are lots of patents on antibody structures. However, there are only so many ways you can string proteins together to make an antibody, and it is not that difficult to imagine a sufficiently powerful computer sequencing every conceivable antibody and publishing those results online. Assuming this would be an anticipatory disclosure, it would prevent anyone from patenting the structure of those antibodies. The computer could not patent the antibody structures itself because it would not know their utility, which is

another requirement for patentability. But an inventive machine would have just wiped out an entire field of human research.

As computers grow increasingly faster, cheaper, and more sophisticated, they are going to play an ever-greater role in the inventive process. It will become standard for creative computers to automate invention. Someone in the chemical sciences who used to discover new chemical compounds through deductive reasoning and trial and error with teams of human researchers will instead use artificial intelligence to find new compounds. Right now, the hypothetical "person having ordinary skill in the art," or PHOSITA, is the benchmark we use to judge inventiveness. If the skilled person uses inventive machines, or is an inventive machine, then the benchmark is very high. It is hard to conceive of an invention that would not be obvious to a sufficiently sophisticated computer. That would essentially mean the end of inventive activity. Everything will be obvious.

Big Data in the Health and Life Sciences: What Are the Challenges for European Competition Law and Where Can They Be Found?

Timo Minssen and Jens Schovsbo

Our goal is to create a European Open Science Cloud to make science more efficient and productive and let millions of researchers share and analyse research data in a trusted environment across technologies, disciplines and borders.

—Carlos Moedas, European Union Commissioner for Research, Science and Innovation

In a recent lead article, *The Economist* highlighted the increasing power and relevance of the new data economy and proclaimed: "The world's most valuable resource is no longer oil, but data."¹ Since data can fuel scientific progress and artificial intelligence (AI), many attempts are being made to stimulate the sharing of data to enhance research and development of new products and services in various technological areas, such as the health and life sciences. But it has also become evident that many data generators are not necessarily willing to share their data. They may refuse to open up their data vaults for many different reasons, ranging from their previous investments in data quality, lack of trust, or the protection of sensitive personal and commercial data. Like other valuable assets, data can be protected by intellectual property rights (IPRs) in some shape or form, often involving a combination of lengthy contracts, trade secrets/the law of confidence, copyright, and/or database rights.² Hence, data are often the subject of litigation, which in addition to these rights may also involve personal data integrity rights and competition law. In that regard, it has been claimed that more regulations are needed to keep the data-generating internet giants at bay and that the new data economy demands a novel approach to antitrust and competition rules.³

This chapter addresses selected competition law aspects of big data in the health and life sciences. Focusing on European Union (EU) competition law, it offers some brief and very general insights into the multiple challenges resulting from the intersection between the big data narrative and European competition law. The aim of the chapter is not to deliver a comprehensive account of emerging case law or describe new practices and approaches of competition authorities in more detail. These will be the focus of a more comprehensive follow-up paper. Here, we intend rather to provide a general and abstract overview of the most fundamental questions that will have to be considered and addressed by European competition law. To this end, we will start out with a short description of the increasing relevance of big data and the protection of data in the health and life sciences. Next we describe how these developments relate to European competition law and why EU authorities, and in particular the European Commission, are increasingly taking notice of big data. This is followed by a brief analysis of what the main challenges are and where they can be found, which allows us to draw some initial conclusions.

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1 *The Economist*, "The World's Most Valuable Resource Is No Longer Oil, but Data," 6 May 2017, <https://www.economist.com/news/leaders/21721656-data-economy-demands-new-approach-antitrust-rules-worlds-most-valuable-resource>.

2 Rosie Burbidge, "Medical Data in a Twist—Technomed v Bluecrest," *IPKat blog*, 28 September 2017, <http://ipkitten.blogspot.dk/2017/09/medical-data-in-twist-technomed-v.html>, commenting on the recent High Court decision in *Technomed v. Bluecrest* [2017] EWHC 2142 about the rights in databases and the potential intellectual property dangers, including copyright infringement, that can become relevant when a business relationship terminates.

3 Ibid.

1. Challenges at the Intersection of Big Data, Intellectual Property Rights, and Competition Law in the Health and Life Sciences⁴

Multiple factors indicate that "big data" will play a crucial role in the evolution of healthcare and the life sciences. The ongoing paradigm shift is fuelled by rapid technical advances that have greatly enhanced the collection and analysis of information from multiple sources. In addition, US and European authorities and public entities have in recent years developed public platforms and infrastructures that provide access to vast volumes of healthcare knowledge, including clinical trials and selected patient data. Meanwhile, private actors, such as pharmaceutical companies, healthcare providers, laboratories, and insurance companies, have stored many years of research and development (R&D) data in databases and digitalised their patient records. This trend is accompanied by recent initiatives and legislation that are increasing the transparency of various forms of data, such as those from clinical trials.

As a result, researchers, companies, patients, and healthcare providers can now gain access to an enormous volume of personal and biological data. This information can be regarded as "big data"—that is, not only because of its greater volume, but also for its increased variety, velocity, and veracity.⁵ Researchers can mine these data to identify the most effective treatments for particular conditions, to find second and further medical uses, to detect patterns related to drug side effects or hospital readmissions, and to gain other important information that can help patients and reduce costs. Although the data collections may be immense, and the quality of the data is often very variable—depending on different database structures and technical characteristics—rapid technological advances and advanced algorithms have improved the ability of scientists to effectively analyse and use such data. It is expected that these developments will push the trend towards precision medicine and help us to address pressing problems such as divergences in healthcare quality and ever increasing healthcare costs.⁶

In light of these developments and rapid technical advances, significantly facilitating the collection and analysis of information and knowledge from multiple sources, both protection of and access to the data have become ever more critical to the innovation narrative.⁷ The vast prospects of big data and the gradual shift to more "personalised," "open," and "transparent" innovation models highlight the significance of effective and well-calibrated regulation, governance, and use of biological and personal data. At the same time, the ultimate goal of widespread data-sharing, and the risky and costly translation of big data science into safe and efficient "real world" applications, raise multiple

4 Some formulations in this section stem from Timo Minssen's welcome talk at the conference "Legal Dimensions of Big Data in the Health and Life Sciences: From Intellectual Property Rights and Global Pandemics to Privacy and Ethics," May 2016, <http://blogs.harvard.edu/billofhealth/2016/05/24/legal-dimensions-of-big-data-in-the-health-life-sciences-from-intellectual-property-rights-and-global-pandemics-to-privacy-ethics/>.

5 W. Raghupathi and V. Raghupathi, "Big Data Analytics in Healthcare: Promise and Potential," *Health Information Science and Systems* 2.3 (2014).

6 Ibid.

7 See, for example, Michael L. Katz and Carl Shapiro, "Product Introduction with Network Externalities," *Journal of Industrial Economics* 40.1 (1992): 55–83; Mark A. Lemley and Ziv Shafir, "Who Chooses Open-Source Software?" *University of Chicago Law Review* 78.1 (2011): 139–164; and Michael A. Carrier, *Innovation for the 21st Century: Harnessing the Power of Intellectual Property and Antitrust Law* (Oxford: Oxford University Press, 2011).

legal challenges in such areas as public–private research collaborations, data integrity, privacy, and ethics. In addition, we will have to tackle pressing issues at the interface of intellectual property law, competition law, R&D incentives, and commercialisation.

As will be discussed, we will have to ask ourselves and decision-makers if the current legal frameworks need to be recalibrated in specific areas to unlock the full potential of big data in the health and life sciences on an ethically and legally safe and economically sustainable basis. Does our current toolbox contain sufficiently flexible mechanisms, or will we have to think in radically different ways and break new ground?

The intersection between the big data narrative and IPRs, for example, presents a particularly significant challenge when questions of ownership rights to data arise and where ownership is challenged by potential users seeking access to the data. Data analytics or data mining will often involve the copying of, or references to, information or databases, which might be protected by various forms of IPRs in relevant jurisdictions. Where data are not owned or licensed, the user will need to rely on an exception to IPR infringement to use data. This has given rise to fierce controversies between data “owners,” data researchers, and entities that provide enabling technologies, large research infrastructures, and standardisation platforms. These tensions at the interface of big data and IPRs involve complex considerations relating to innovation economics, ownership, exceptions to IPRs, ethics, licensing, and competition law.⁸

In that context, we regard it as problematic that there seems to be so much confusion about the availability, nature, and legal effects of a great variety of often overlapping rights and remedies among multiple stakeholders in big data science. As indicated, a great variety of different IPRs and sui generis rights may apply to various aspects of big data applications. Clearly some rights, such as European database rights and trade secrets, are becoming increasingly important for the commercial protection of big data, whereas other rights that have traditionally played a major role in innovation policy debates, such as patent rights, may not always be applicable and useful for the protection of specific data uses.⁹ At the same time, the full effect and function of some of these IPRs—for example, as data aggregators—for the big data innovation framework are not entirely clear and demand further study. The (un)availability of these IPRs and sui generis rights might result in both a lack of well-calibrated incentives and underinvestment in some areas, and a blocking effect on open innovation and anti-commons scenarios in other areas. In addition, their interplay with recent data transparency initiatives and the potential impact on open innovation scenarios or public–private partnerships need to be elucidated. It can thus be assumed that nuanced approaches and IPR user modalities will have to be considered for different technological applications, and that these need to be discussed and addressed on a case-by-case basis.¹⁰

Be that as it may, in the following we will focus on yet another important challenge relating to big data and IPRs, the interface of big data and European competition law.

8 Ibid.

9 See T. Minssen and J. Pierce, “Big Data and Intellectual Property Rights in the Health and Life Sciences,” in G. Cohen, H. Fernandez Lynch, E. Vayena, and U. Gasser (eds), *Big Data, Health Law, and Bioethics* (Cambridge: Cambridge University Press, 2018), 311–323.

10 Ibid.

2. The Interface between Big Data and European Competition Law

Competition law (antitrust) agencies in both the United States and the European Union are taking note of big data, and there is an increasing trend to examine closely its collection, use, and accessibility for anticompetitive effects.¹¹ Defining the role of competition law in this highly dynamic area is, however, both controversial and complicated. The controversies are to some extent related to the discussions about the general role of competition law and the extent to which regulators should intervene in market developments. Historically, the European and US agencies have been well known for their different approaches to the assessment of anticompetitive behaviour ("interventionist" versus "non-interventionist").¹²

Apart from these recognised concerns, applying competition law in "the digital economy" is particularly complex. Whereas some see its fast-moving, technology-driven nature as calling for competition law intervention to discipline markets and control the market power of the digital giants, others think that the costs of applying competition law's norms to such markets is likely to do more harm than good.¹³

But what is the potential for the applicability of EU competition law in cases involving big data, and what will be the general difficulties in applying the traditional competition law norms in this particular field?¹⁴

3. What Are the Challenges and Where Do They Arise

Competition law may affect the market for big data and the behaviour of its holders in different ways. In the following, we will focus on the rule that prevents the misuse of a dominant position (i.e. Treaty on the Functioning of the European Union (TFEU), Article 102), and that may serve to facilitate data sharing if access is restricted because of misuse of a dominant position, and on the provision that regulates the conditions for the sharing of data via licensing agreements (i.e. Article 101).¹⁵

11 See also Margrethe Vestager, "Big Data and Competition" (Brussels: European Commission, 2016), http://ec.europa.eu/commission/2014-2019/vestager/announcements/big-data-and-competition_en on data as an asset and access to data for innovation; Federal Trade Commission, "Big Data: A Tool for Inclusion or Exclusion?" (Washington, DC: Federal Trade Commission, 2016), <https://www.ftc.gov/system/files/documents/reports/big-data-tool-inclusion-or-exclusion-understanding-issues/160106big-data-rpt.pdf> emphasising the link between big data, medicine and healthcare; and G. Sivinski, A. Okuliar, and L. Kjolbye, "Is Big Data a Big Deal? A Competition Law Approach to Big Data," *European Competition Journal* 13.2–3 (2017): 119–227.

12 See, for example, J. Schovsbo, "Fire and Water Make Steam: Redefining the Role of Competition Law in TRIPS," in A. Kur and M. Levin (eds), *Intellectual Property Rights in a Fair World Trade System* (Cheltenham, UK: Edward Elgar, 2011), 308–358.

13 For an overview see, for example, A. Capobianco and A. Nyeso, "Challenges for Competition Law Enforcement and Policy in the Digital Economy," *Journal of European Competition Law and Practice* 9.1 (2018): 19–27. These authors also point out that at the Hearing on the Digital Economy of the Organisation for Economic Co-operation and Development in 2012, a broad consensus emerged that competition law had an important role to play in the digital economy (in particular as the markets mature); see <http://www.oecd.org/daf/competition/The-Digital-Economy-2012.pdf>.

14 The trend for competition rules to intervene in the rights of data owners is also occurring at the level of European member states. For example, in the "Cegecim" Decision no. 14-D-06 (7 August 2014), the French competition authority found that the refusal of access to data to those using rival software was unjustified.

15 We focus on the central competition law rules in TFEU Articles 101 and 102. It should be noted, however, that the special competition rules regarding mergers have also been applied in cases involving big data. In the merger leading to Thomson Reuters, Case COMP/M.4726, *Thomson Corporation/Reuters Group*, of 19 February 2008, regulators in the EU and the

TFEU Article 102 bans the misuse of a dominant position by one or more undertakings. Unlike in the United States, for example, the Court of Justice of the European Union (CJEU) has ruled that this provision may be used for the granting of compulsory licences (even) to information protected by IPR. Article 102 does not ban "misuse" in the abstract; it is only the misuse of "a dominant position" that is covered by the prohibition. A "dominant position" is characterised by the ability of a firm or group of firms to behave to an appreciable extent independently of its competitors, its customers, and ultimately its consumers.¹⁶ In order to determine whether or not a company holds a "dominant position," the "relevant market" must first be established. The starting point for defining this is an assessment of the range of products that are viewed as substitutes by the consumer. Normally, the assessment involves the expected effects of a "small but significant and non-transitory increase in price" (the SSNIP test) on demand substitution.¹⁷ Having then established a "dominant" position, the next hurdle for a third party wanting access to the data and relying on the granting of a compulsory licence under Article 102 is to prove that a "misuse" has taken place. For information protected by IPR, the CJEU developed what is known as the "indispensability" test¹⁸ as the baseline for compulsory licensing. According to this rule, "misuse" may be found to exist provided that the following cumulative conditions have been satisfied: (1) the refusal is preventing the emergence of a new product for which there is a potential consumer demand; (2) the refusal is unjustified; and (3) it is such as to exclude any competition on a secondary market. The requirement of a "new product" is normally stated to constitute an "extra requirement" vis-à-vis other types of rights involved in cases of misuse and to make it clear that compulsory licensing only applies to holders of IPRs in "*exceptional circumstances*."¹⁹ More concretely, the new product ("innovation") criterion would seem to rule out access in order to simply compete on the product market with the incumbent rights-holder. For non-proprietary information, the threshold for intervention is lower and therefore access may (in principle) be granted with the aim of entering into direct competition with the holder of the information.

Applying these principles in a case where a third party requires access to data involves a number of complicated assessments, including how to define the "relevant market" and distinguishing between the (legal) use of and the (illegal) misuse of market power.²⁰ It is also far from clear

United States had concerns stemming from big data. Both took the position that the need for a company to collect vast amounts of financial data to effectively compete with the merged firm in the market for data terminals created a significant barrier to entry. To address this concern, both authorities approved the merger on the condition that the merged firm would make copies of its database available for purchase by existing and new potential competitors; see http://ec.europa.eu/competition/mergers/cases/decisions/m4726_20080219_20600_en.pdf. For a discussion, see G. Sivinski, A. Okuliar, and L. Kjolbye, "Is Big Data a Big Deal? A Competition Law Approach to Big Data," *European Competition Journal* 13.2–3 (2017): 119–227.

16 Commission Notice (EC) on the Definition of Relevant Market for the Purposes of Community Competition Law, [1997] OJ C 372, p. 5, point 10 with reference to Case 85/76, *Hoffmann-La Roche & Co. AG v. Commission* [1979] ECR 1979–461.

17 *Ibid.*, point 15.

18 The "indispensability" test is derived from Joined cases C-241/91 P and C-242/91 P, *RTE & ITP v. Commission* [1995] ECLI:EU:C:1995:98 and Case C-418/01, *IMS Health GmbH & Co. OHG v. NDC Health GmbH & Co. KG* [2004] ECLI:EU:C:2004:257, para. 38. See also Decision COMP/AT.39612 "Perindopril (Servier)" of 9 July 2014.

19 Generally, see J. Schovsbo, "Fire and Water Make Steam: Redefining the Role of Competition Law in TRIPS," in A. Kur and M. Levin (eds), *Intellectual Property Rights in a Fair World Trade System* (Cheltenham, UK: Edward Elgar, 2011), 308–358. The exceptional circumstances test was confirmed by Case 170/13, *Huawei Technologies Co. Ltd v. ZTE Corp. and ZTE Deutschland GmbH* [2015] ECLI:EU:C:2015:477, paras 46–47.

20 To a large extent these complications are common to most markets in the digital economy; see A. Capobianco and A. Nyso, "Challenges for Competition Law Enforcement and Policy in the Digital Economy," *Journal of European Competition Law and Practice* 9.1 (2018): 19–27.

whether and how competition authorities would apply the “exceptional circumstances” test—and in particular the “new product” criterion—to “big data” that are not protected by IPRs or that involve (parts) that are considered to be trade secrets.

For health data it is further unclear to what extent the protection of personal data would prevent the issue of compulsory licences *per se*. The intersection between competition law and data protection rules has become an ever more important factor in cases related to big data.²¹ Data protection rules, such as the EU’s General Data Protection Regulation (GDPR)²² or international data transfer agreements, such as the Privacy Shield agreement²³ between the United States and Europe, often restrict the ability of public and private commercial research to generate, store, use, and transfer data. In particular, the GDPR codifies regulatory requirements that will surely have a considerable impact on the Commission’s assessment of (anti-)competitive practices. This includes new types of considerations already anticipated by the Commission in the assessment of the case law already mentioned, such as increasingly relevant evaluations of data portability and the prospective future behaviour of merged entities.²⁴ Arguably, the CJEU decided in *Asnef-Equifax and Administración del Estado*²⁵ that privacy considerations as such should not be the focus of competition law. Yet, and in accordance with the CJEU’s findings, it is clear that data protection rules must be considered carefully for the purposes of establishing the relevant counterfactual, to the same extent as any other regulatory requirement would be considered by the Commission.²⁶

Additional problems also apply to the competition law assessment of licensing agreements. Normally the licensing of technology is said to promote competition by:

- allowing innovators to earn returns to cover at least part of their research and development costs;
- leading to a dissemination of technologies, which may create value by reducing the production costs of the licensee or by enabling the licensee to produce new or improved products;
- combining the licensor’s technology with the assets and technologies of the licensee;

21 In 2016, Commissioner Vestager gave three different speeches addressing the competition aspects of big data and privacy: Margrethe Vestager, “Big Data and Competition” (Brussels: European Commission, 2016), http://ec.europa.eu/commission/2014-2019/vestager/announcements/big-data-and-competition_en; Margrethe Vestager, “Making Data Work for Us,” speech to data ethics event on Data as Power, Copenhagen, 9 September 2016; and Margrethe Vestager, “Competition in a Big Data World,” speech at DLD 16, Munich, 17 January 2016.

22 Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the Protection of Natural Persons with Regard to the Processing of Personal Data and on the Free Movement of Such Data, and Repealing Directive 95/46/EC [2016] L119/1 (General Data Protection Regulation/GDPR). The Regulation applies from 25 May 2018; see Article 99.

23 See the European Commission on the EU–US Privacy Shield: https://ec.europa.eu/info/law/law-topic/data-protection/data-transfers-outside-eu/eu-us-privacy-shield_en; note that many details of this agreement are still very controversial.

24 M. Kadar and M. Bogdan, “‘Big Data’ and EU Merger Control: A Case Review,” *Journal of European Competition Law and Practice* 8.8 (2017): 479–491, at 486, referring to Article 20 of the GDPR.

25 See Case C-238/05 *Asnef-Equifax and Administración del Estado* [2006] ECR I-11145, para. 63.

26 M. Kadar and M. Bogdan, “‘Big Data’ and EU Merger Control: A Case Review,” *Journal of European Competition Law and Practice* 8.8 (2017): 479–491.

- promoting the coordinated development of technologies that are in a blocking relationship;
- removing obstacles to the sale of the licensee's product.²⁷

However, licensing agreements also often limit competition and therefore they are not always accepted by competition law as such. The EU TFEU Article 101 (the so called "cartel rule") states that all agreements that have an adverse effect on competition between member states are void. Furthermore, TFEU Article 101(3) exempts competition law constraints from the prohibition in Article 101(1) for agreements that, despite containing anticompetitive elements, have overall pro-competitive effects.

In future cases, courts and competition authorities will most likely rely on the basic principles in the EU Technology Transfer block exemption Regulation.²⁸ This exempts a number of important restrictions regarding access to markets and consumers (within the EU) and it is directly applicable to agreements concerning, *inter alia*, patents and know-how. Defining the relevant market is also central for the application of Article 101. The Regulation thus includes the following market definitions in Article 1:

(j) "relevant product market" means the market for the contract products and their substitutes, that is to say all those products which are regarded as interchangeable or substitutable by the buyer, by reason of the products' characteristics, their prices and their intended use;

(k) "relevant technology market" means the market for the licensed technology rights and their substitutes, that is to say all those technology rights which are regarded as interchangeable or substitutable by the licensee, by reason of the technology rights' characteristics, the royalties payable in respect of those rights and their intended use;

As mentioned before, defining the relevant product and technology markets is inherently complicated in the big data context and there are many reasons for this. This is *inter alia* demonstrated by the difficulties in assessing which technologies (products) may be substitutes.

Considering the volume of data, for example, simply having more data than anyone else does not necessarily protect a company from competition.²⁹ Similar complexities occur when assessing the nature and relevance of the data: expected anticompetitive outcomes assume to a significant degree that all data are competitively useful, and that most data are unique and without reasonable substitutes. This disregards the counterfactual reality that in most cases the data are not essential to competing or there exist reasonable substitutes such that the way in which the owner or controller may choose to leverage those data should not raise a significant competition issue.³⁰

27 Based on "Communication from the Commission: Guidelines on the Application of Article 101 of the Treaty on the Functioning of the European Union to Technology Transfer Agreements," OJ C 89, 28 March 2014, 3–50, point 17; and "Antitrust Guidelines for the Licensing of Intellectual Property: Issued by the US Department of Justice and the Federal Trade Commission," 12 January 2017, point 2.3.

28 Commission Regulation (EU) No. 316/2014 of 21 March 2014 on the Application of Article 101(3) of the Treaty on the Functioning of the European Union to Categories of Technology Transfer Agreements (Text with EEA Relevance), OJ L 93, 28 March 2014, 17–23.

29 For an excellent and very detailed discussion of these issues, see G. Sivinski, A. Okuliar, and L. Kjolbye, "Is Big Data a Big Deal? A Competition Law Approach to Big Data," *European Competition Journal* 13.2–3 (2017): 119–227.

30 Ibid.

4. Conclusions

In summing up, competition law in the EU is omnipresent and potentially very important for companies that rely on big data to control large market shares. For such companies, competition law needs to be taken into account in decisions on mergers and in instances of refusal to license. Even for companies without much market power, licensing agreements that contain provisions on territorial limitations would often need to take competition law concerns into account. Seen from a regulatory perspective, competition law is characterised by providing for general mechanisms, which apply *ex post*. Furthermore, competition law intervention always has to be triggered by specific market behaviour that deviates from the generally acceptable baseline. For "big data," the scope and potential of competition law's provisions are very hard to judge. Defining the relevant market in fast-moving technologies is inherently difficult. In addition, assessing market behaviour and drawing the line between wanted and unwanted practices in newly developed or developing markets where no firm norms of behaviour have yet crystallised is a daring task. Here competition authorities will be sailing between the Scylla of the costs of over-enforcement (e.g. no economy-of-scale advantages) and the Charybdis of under-enforcing (e.g. market foreclosure).

In light of these complexities and the relevance of big data in the digitalised health and life sciences, we regard it as imperative that the legal issues raised in relation to big data and artificial intelligence are given the highest priority by the European Commission. Hence, we are glad that the European Commission now appears to be devoting considerable effort and resources to addressing the competition aspects of big data and privacy in order to test whether its jurisdictional criteria are still adequate to tackle all the issues entailed by big data and AI. As we have demonstrated, the growing relevance of big data issues is not limited to applications in the information technology sector. Many issues that have so far been predominantly debated in that sector are now rapidly extending to other important technological fields, such as the increasingly data-driven healthcare and life sciences. This concern includes problem areas that could not be addressed in this chapter, such as the "fair, reasonable, and non-discriminatory" (FRAND) licensing debates about standard-essential IPRs, patent pools, and clearing houses, which are slowly becoming relevant even in the health and life sciences.³¹

As the importance of big data increases in all areas of society and the economy, and as the aspiration of free data-sharing encounters harsh business realities, it can be expected that data-related questions will be disputed more frequently in future European Commission cases. After all, many wars have been fought over gold, diamonds, and oil. It is also clear that if regulators want to avoid a data- and AI-driven economy in individual countries and internationally that is completely controlled by a few giants, they will need to step up to the game now.³²

31 One example is MPEG LA's initiative in December 2016 to introduce a licensing model for CRISPR gene-editing technology, which clearly shows that key stakeholders involved in one-stop licensing in the information and communications technology sector believe in applying their model and experience within synthetic biology and data-driven systems biology. This development needs to be put in a broader perspective, evaluating how this initiative fits within the unique culture of the systems biology and synthetic biology communities. For further information, see *Business Wire*, "MPEG LA Initiative to Address CRISPR Licensing: One-Stop Access Will Accelerate Advances in New Medicines, Organ Transplants and Agriculture," 6 December 2016, <http://www.businesswire.com/news/home/20161206006182/en/MPEG-LA-Initiative-Address-CRISPR-Licensing>; cf. MPEG LA, "Terms and Procedures for CRISPR-Cas9 Patent Submissions," <http://www.mpegla.com/main/pid/CRISPR/Terms.aspx>.

32 Cf. *The Economist*, "The World's Most Valuable Resource Is No Longer Oil, but Data," 6 May 2017, <https://www.economist.com/news/leaders/21721656-data-economy-demands-new-approach-antitrust-rules-worlds-most-valuable-resource>; see also *The Economist*, "The Battle in AI: Artificial Intelligence Looks Tailor-Made for Incumbent Tech Giants. Is That a Worry?" 7 December 2017, <https://www.economist.com/news/leaders/21732111-artificial-intelligence-looks-tailor-made-incumbent-tech-giants-worry-battle?frsc=dg%7Ce>.

Mobility of Research: Patent Data and Inventor Information

Francesco Lissoni and Gabriele Cristelli

1. Introduction

Economic studies of technological change have long exploited patents as indicators of innovation activity. As explained by Griliches' classic survey,¹ patent data are easily available, cover many countries, and are rich in technical information, thanks to their fine classification. The United States Patent and Trademark Office (USPTO) and, from the 1980s, the European Patent Office (EPO) are the most heavily used data sources, with the NBER Patent and Citations Data File² and EPO's Worldwide Patent Statistical Database (PATSTAT) being the main consolidated open access patent data repositories (the latter being based on the DOCDB database, which assembles all the prior art information used by EPO examiners). These datasets provide researchers with all the bibliographical information found on patent application documents, including the claimed invention's characteristics, the names and address of the entity or entities requesting intellectual property (IP) protection, and the inventors responsible for its conception and reduction to practice.

Inventors are an important class of knowledge workers, especially in sectors where research and development (R&D) is a key innovation input. Innovation scholars' interest in their activity derives from the relationship of human and social capital with technical and scientific discovery. Besides examining scientists' and engineers' productivity, researchers have explored the role of spatial and social distance between inventors for the diffusion of knowledge, high-skilled immigration phenomena, and the impact of IP rights on scientific progress. Many of these studies have jointly exploited inventor information and data on citations of prior art or non-patent literature, mostly declared by applicants or inserted in search reports by patent examiners. While carrying a lot of statistical noise,³ they can provide a sketch of the knowledge debt running from citing to cited inventors, also offering a measure of patents' relative quality and value.⁴

Properly using inventor data exposes researchers to multiple technical challenges. Two chief concerns are the correct geolocalisation of inventors and patent applicants, and their unique identification across different patent applications and over time.

In what follows we provide an overview of economic research on inventors, touching upon the main findings and technical issues highlighted by the scholarly community over the past decades. We then focus on a special topic, namely the study of inventorship as an attribution right.

2. Inventors and Economics Research

2.1 Geographical Studies: Co-location, Inventors' Networks, and International Mobility

The information on inventors (and applicants) contained in patent databases has allowed researchers to geolocalise inventive activity in an increasingly sophisticated way. A broad line of research has

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- 1 Z. Griliches, "Patent Statistics as Economic Indicators: A Survey," *Journal of Economic Literature* 28 (1990): 1661–1707.
 - 2 B.H. Hall, A.B. Jaffe, and M. Trajtenberg, "The NBER Patent Citations Data File: Lessons, Insights and Methodological Tools," NBER Working Paper No. 8498 (Cambridge, MA: National Bureau of Economic Research, 2001).
 - 3 J.M. Kuhn, K. Younge, and A. Marco, "Patent Citations Reexamined: New Data and Methods," 2017, <http://dx.doi.org/10.2139/ssrn.2714954>.
 - 4 A.B. Jaffe and G. De Rassenfosse, "Patent Citation Data in Social Science Research: Overview and Best Practices," *Journal of the Association for Information Science and Technology* 68.6 (2017): 1360–1374; and P. Moser, J. Ohmstedt, and P.W. Rhode, "Patent Citations: An Analysis of Quality Differences and Citing Practices in Hybrid Corn," *Management Science* 64.4 (2017): 1926–1940.

investigated knowledge production's spatial differences, starting from Jaffe's seminal contribution.⁵ A major theme has been the assessment of geographical localisation of knowledge flows. Challenging Paul Krugman's statement on their invisibility,⁶ Jaffe, Trajtenberg, and Henderson exploited patent citations as "paper trails" of knowledge flows and introduced the first test to assess the strength of inventors' or applicants' co-location for determining knowledge spillovers (called the JTH test after the co-authors).⁷ The JTH test consists in taking a sample of pairs of citing patents and the patents they cited (excluding self-citations at the firm level) and comparing them with a control sample composed of patents with the same application year and technological field as the citing ones, but with no citation links to the patents the latter cited. To the extent to which the rate of co-location (at the city or state level) of the inventors of the cited–citing pairs is higher than that of the inventors of the cited–control pairs, the JTH test is indicative of the tendency of cross-firm citations to concentrate in space beyond what one would expect by simply looking at the geographical distribution of patents based on technology.

After taking into account the methodological reservations raised by Thompson and Fox-Kean⁸ and Thomson,⁹ the JTH test has become the basis of the patent-based geography of innovation literature. Follow-up research has concentrated on disentangling how different dimensions of geographical distance affect knowledge diffusion, and on questioning the original interpretation of their evidence by Jaffe, Trajtenberg, and Henderson in 1993. Concerning distance, Jaffe et al. treated it as a binary variable, simply focusing on whether patent citations occur mostly within states or metropolitan areas, irrespective of the relative geolocalised position of the patents. Murata et al. go beyond this limitation by developing a physical distance-based test able to capture cross-boundary, spatially close knowledge spillovers.¹⁰ They find that simple, continuous geographical distance also matters, even when building the control sample at a finer technological aggregation. At the same time, Singh and Marx show that physical distance and administrative borders play independent roles as obstacles to knowledge diffusion,¹¹ both of them being significant when inserted in an exercise à la Jaffe et al. Belenzon and Schankerman, who concentrate their attention on university–industry knowledge spillovers, reach similar

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- 5 Specifically, Jaffe modelled the spatial distribution of corporate patents across states of the United States of America and broad technological areas as a function of the states' public and private R&D expenditure, providing evidence of the existence of geographically mediated spillovers from university research to commercial innovation; see A.B. Jaffe, "Real Effects of Academic Research," *American Economic Review* 79.5 (1989): 957–970.
 - 6 "Knowledge flows ... are invisible; they leave no paper trail by which they may be measured and tracked, and there is nothing to prevent the theorist from assuming anything about them that she likes... So while I am sure that true technological spillovers play an important role in the localization of some industries, one should not assume that this is the typical reason—even in the high technology industries themselves"—P. Krugman, *Geography and Trade* (Cambridge, MA: MIT Press, 1991), 53–54.
 - 7 A.B. Jaffe, M. Trajtenberg, and R. Henderson, "Geographic Localization of Knowledge Spillovers as Evidenced by Patent Citations," *Quarterly Journal of Economics* 108 (1993): 577–598.
 - 8 P. Thompson and M. Fox-Kean, "Patent Citations and the Geography of Knowledge Spillovers: A Reassessment," *American Economic Review* 95.1 (2005): 450–460.
 - 9 P. Thompson, "Patent Citations and the Geography of Knowledge Spillovers: Evidence from Inventor- and Examiner-Added Citations," *Review of Economics and Statistics* 88 (2006): 383–38
 - 10 Y. Murata, R. Nakajima, R. Okamoto, and R. Tamura, "Localized Knowledge Spillovers and Patent Citations: A Distance-Based Approach," *Review of Economics and Statistics* 96.5 (2014): 967–985.
 - 11 J. Singh and M. Marx, "Geographic Constraints on Knowledge Spillovers: Political Borders vs. Spatial Proximity," *Management Science* 59 (2013): 2056–2078.

conclusions, showing that citations to patents filed by US universities at the USPTO decline sharply with distance from the universities and are strongly constrained by state borders.¹²

An important extension has been provided by studies considering the role of social distance between inventors, in addition to that of spatial distance. Agrawal et al. focus on socially mediated knowledge flows by looking at inventors who move across US cities.¹³ They demonstrate how patents by inventors in the cities they reach after moving are disproportionately cited by new patents by inventors still residing in their pre-move locations; this is interpreted as the effect of persistent social ties held by the inventors across cities. Breschi and Lissoni show that the inventors' inter-firm mobility occurs largely within the same locations, and many citations occurring between companies are in fact personal self-citations by mobile inventors.¹⁴ The same inventors, by joining different teams, also end up building a localised collaboration network that largely explains the observed spatial patterns of citation flows (social distance between any two inventors is measured by the number of collaborative ties that separate them). These findings are confirmed by Miguélez and Moreno, who study the determinants of cross-regional mobility of inventors of EPO applications for a sample of European countries.¹⁵ By tracking cross-regional movements of inventors, the authors find both descriptive and analytical evidence on the critical role of spatial distance and country borders in hampering the mobility of this specific class of knowledge workers.

A further development deals with ethnical distance and its influence on knowledge diffusion along immigrant inventors' networks within host countries and across national borders. Agrawal et al. analyse patent citations and their probability of taking place disproportionately among individuals linked by common ethnic origins.¹⁶ Looking only at inventors with Indian names in the United States and Canada, they find evidence of such a co-ethnic effect. Interestingly, co-location is also found to predict patent citations, but with a remarkably lower marginal effect for inventors sharing the same ethnicity. Finally, co-ethnicity and co-location appear to be substitute determinants of the probability of observing citation links between patents. Breschi et al. extend this type of analysis, including other nationality groups of United States-resident foreign inventors (China, India, the Islamic Republic of Iran, Japan, and the Republic of Korea for Asia; and France, Germany, Italy, Poland, and the Russian Federation for Europe), and controlling for path lengths within their social networks.¹⁷ Co-ethnicity is found to be a significant predictor of knowledge flows, although only for Asian and Russian inventors and only for great social distances in the network, possibly compensating for the lack of other professional links.

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- 12 S. Belenzon and M. Schankerman, "Spreading the Word: Geography, Policy, and Knowledge Spillovers," *Review of Economics and Statistics* 95.3 (2013): 884–903.
 - 13 A. Agrawal, I. Cockburn, and J. McHale, "Gone but Not Forgotten: Knowledge Flows, Labor Mobility, and Enduring Social Relationships," *Journal of Economic Geography* 6.5 (2006): 571–591.
 - 14 S. Breschi and F. Lissoni, "Mobility of Skilled Workers and Co-Invention Networks: An Anatomy of Localized Knowledge Spillovers," *Journal of Economic Geography* 9.4 (2009): 439–468.
 - 15 E. Miguélez and R. Moreno, "What Attracts Knowledge Workers? The Role of Space and Social Networks," *Journal of Regional Science* 54.1 (2014): 33–60.
 - 16 A. Agrawal, D. Kapur, and J. McHale, "How Do Spatial and Social Proximity Influence Knowledge Flows? Evidence from Patent Data," *Journal of Urban Economics* 64.2 (2008): 258–269.
 - 17 S. Breschi, F. Lissoni, and E. Miguélez, "Foreign Inventors in the US: Testing for Diaspora and Brain Gain Effects," *Journal of Economic Geography* 17.5 (2017): 1009–1038.

Inventor data have also been exploited to study the impact of high-skilled immigrants on their host countries' innovation systems.¹⁸ A salient example is offered by Kerr and Lincoln, who employ USPTO data to test whether variations in US H-1B visa admissions correspond to variations in the innovation rates in cities whose labour market are heavily dependent on holders of such visa.¹⁹ They estimate that a 10 percent surge in the H-1B population increases Indian and Chinese invention (proxied by patent applications) by 1–4 percent, with roughly no negative impact on locals (that is, limited crowding-out effects). Hunt and Gauthier-Loiselle show how immigrant inventors account for a disproportionate share of scientists and engineers listed on US patents, and how increases in the population of foreign-born college graduates considerably boost patents per capita at the state level.²⁰

2.2 Intellectual Property Rights in Science: Academic Inventors and "Anti-commons" Effects

A second strand of economics literature employing inventor data has dealt with the role of formal intellectual property rights (IPRs) in science. Following the increased proclivity of universities and public research centres to seek patent protection to commercialise their scientific output,²¹ researchers have investigated the effect of academic patenting on scientists' performance and universities' knowledge production processes. Most of the studies link inventor records with academic researchers' profiles and publication histories, testing the legitimacy of worries about IPRs' potential negative influence on science, such as the diversion of scholars' efforts from basic to "more applied" research, and alleged "anti-commons" effects,²² hindering cumulative scientific discovery.

Agrawal and Henderson present one of the first enquiries,²³ focusing on MIT's Department of Mechanical and Electrical Engineering. Relating professors' publication output and citations received to their corresponding patents, they highlight how patent counts do not predict higher publication propensity, but they positively influence the amount of citations received by the articles. They interpret these findings as patents signalling higher research impact. Azoulay et al. employ a longitudinal database on US-based researchers and provide a slightly different picture, finding patenting activity to positively influence the number of scientific publications while weakly impacting their quality, as measured by the journals' impact factor.²⁴ Azoulay

18 A comprehensive overview of studies dealing with migration and innovation is offered by F. Lissoni, "International Migration and Innovation Diffusion: an Eclectic Survey," *Regional Studies* 53.5 (2018): 702–714.

19 W.R. Kerr and W.F. Lincoln, "The Supply Side of Innovation: H-1B Visa Reforms and US Ethnic Invention," *Journal of Labor Economics* 28.3 (2010): 473–508.

20 J. Hunt and M. Gauthier-Loiselle, "How Much Does Immigration Boost Innovation?" *American Economic Journal: Macroeconomics* 2.2 (2010): 31–56.

21 A.B. Jaffe and J. Lerner, "Reinventing Public R&D: Patent Policy and the Commercialization of National Laboratory Technologies," *RAND Journal of Economics* 32.1 (2001): 167–198; and J.G. Thursby and M.C. Thursby, "Who Is Selling the Ivory Tower? Sources of Growth in University Licensing," *Management Science* 48.1 (2002): 90–104.

22 P. David, "Will Building 'Good Fences' Really Make 'Good Neighbors' in Science?" *SIEPR Discussion Paper* No. 00-33 (Stanford, CA: Stanford Institute for Economic Policy Research, 2001).

23 A. Agrawal and R. Henderson, "Putting Patents in Context: Exploring Knowledge Transfer from MIT," *Management Science* 48.1 (2002): 44–60.

24 P. Azoulay, W. Ding, and T. Stuart, "The Impact of Academic Patenting on the Rate, Quality and Direction of (Public) Research Output," *Journal of Industrial Economics* 57.4 (2009): 637–676.

et al. further exploit the same data source, showing how patenting events are preceded by publication surges, emphasising shocks in scientific opportunities as the main drivers of academic patenting.²⁵ Fabrizio and Di Minin find similar results for a sample of US researchers over a 20-year time frame. But while reporting increased publication rates for academic inventors, they also emphasise how the citations received by the articles fall for individuals reporting more than one patent application, suggesting a negative correlation between scientific output quality and "serial" patent activity.²⁶ Breschi et al. examine the Italian experience.²⁷ Their analyses point to a productivity gap between patenting and non-patenting scholars, with the former reporting higher publication rates and more cited papers, which further increase after the patenting event. The latter effect lasts longer for serial academic inventors—that is, scholars reporting more than one patent. Overall, none of the cited studies seems to find evidence of the recent increase in academic patenting affecting negatively scientific publishing at the individual level, but, quite the contrary, they often find a positive effect.

Murray and Stern explore instead systemic effects, namely the possibility that IPRs on science-based inventions stand in the way of cumulative research.²⁸ They do so by comparing articles from a leading scientific outlet (*Nature Biotechnology*) and distinguishing between those that are associated with a USPTO patent grant and those that are not. Publications related to IPRs are found to receive more citations than their counterparts. Interestingly, the intensity of citations modestly decreases after the connected patent is published,²⁹ which suggests the potential presence of an "anti-commons" effect (scientists working on topics close to the invention covered by the patent change research direction when they discover the extent of proprietary results). Nevertheless, the small quantitative effect and the possible "measurement inefficiencies" of the citations prevent the authors from strongly claiming the existence of a negative influence of IPRs on cumulative scientific efforts.

2.3 Inventors and Labour Market Outcomes

The latest contributions to economic research on inventors come from studies linking patent/inventor records with micro-level information on earnings, employment, or educational outcomes gathered from the registers of administrative agencies (e.g. social security administration, national fiscal authorities). The resulting databases often encompass full populations, reaching high degrees of detail on many individual dimensions (e.g. date of birth, gender, addresses), crucial information for studies whose identification strategies control for selection on observable characteristics. The issues investigated deal with inventors' social extraction, educational background, and income trajectories, classic topics

25 P. Azoulay, W. Ding, and T. Stuart, "The Determinants of Faculty Patenting Behavior: Demographics or Opportunities?" *Journal of Economic Behavior and Organization* 63.4 (2007): 599–623.

26 K. Fabrizio and A. Di Minin, "Commercializing the Laboratory: Faculty Patenting and the Open Science Environment," *Research Policy* 37.5 (2008): 914–931.

27 S. Breschi, F. Lissoni, and F. Montobbio, "The Scientific Productivity of Academic Inventors: New Evidence from Italian Data," *Economics of Innovation and New Technology* 16.2 (2007): 101–118; and S. Breschi, F. Lissoni, and F. Montobbio, "University Patenting and Scientific Productivity: A Quantitative Study of Italian Academic Inventors," *European Management Review* 5.2 (2008): 91–109.

28 F. Murray and S. Stern, "Do Formal Intellectual Property Rights Hinder the Free Flow of Scientific Knowledge? An Empirical Test of the Anti-Commons Hypothesis," *Journal of Economic Behavior and Organization* 63.4 (2007): 648–687.

29 The authors use only USPTO patents granted before 2001, when the granting and publication dates coincided.

of research agendas in labour economics, one of the first fields to mine administrative agencies' datasets.³⁰

In the United States, Bell et al. and Jaravel et al. link USPTO patent data with tax records containing information on inventors' residences, employment history and income. Bell et al. deal with inventors' life cycles, finding that children born to high-income parents are much more likely to become inventors than children with a low-income family background.³¹ Jaravel et al. analyse inventors' team dynamics, assessing inventors' earnings and patenting quality losses after the premature death of a co-inventor. Causal estimates of the effect of such an end to a collaboration point to a large and long-lasting decline in earnings (−3.8 percent after eight years), total earnings (−4 percent after eight years), and patent citations received (−15 percent after eight years).³² In Germany, Dorner et al. link EPO patent data with the Integrated Employment Biographies database,³³ a source of individuals' employment histories. They study the effects of social ties on inventors' relocation from eastern to western Germany after the reunification of the country, finding western German regions with stronger historically determined ties across the border attracting more inventors from eastern Germany, but of lesser quality (more productive inventors found their way to core western German regions regardless of pre-existing social ties). In Finland, Toivanen and Väänänen and Aghion et al. link EPO patent data with the Finnish longitudinal employer/employee database (administrative data on individuals' labour market status and salaries), the Finnish population census (information on parents' education and income), and Finnish Defence Force data on IQ scores (Aghion et al. only). Toivanen and Väänänen study the relationship between engineering education and inventive output, highlighting a positive and significant effect of a university engineering degree on individuals' propensity to patent.³⁴ Aghion et al. look at both the probability of becoming an inventor and the economic returns to patenting an invention.³⁵ They report on how the likelihood of becoming an inventor is highly correlated with parental income—although the correlation is largely driven by parents' education and children's IQ test scores—and how patenting significantly increases the annual wage rate of an inventor over a prolonged period afterwards, with co-workers in the same firm also benefiting from the patented invention in terms of earnings. Jung and Ejermo³⁶ and Zheng

30 O. Ashenfelter and D. Card, "Using the Longitudinal Structure of Earnings to Estimate the Effect of Training Programs," *Review of Economics and Statistics* 67.4 (1985): 648–660; J.D. Angrist, "Lifetime Earnings and the Vietnam Era Draft Lottery: Evidence from Social Security Administrative Records," *American Economic Review* 80.3 (1990): 313–336; J.D. Angrist, "Estimating the Labor Market Impact of Voluntary Military Service Using Social Security Data on Military Applicants," *Econometrica* 66.2 (1998): 249–288; and L.F. Katz and B.D. Meyer, "Unemployment Insurance, Recall Expectations, and Unemployment Outcomes," *Quarterly Journal of Economics* 105.4 (1990): 973–1002.

31 Specifically, children whose parents are in the top 1 percent of the income distribution are found to be 10 times as likely to become inventors as children from below-median income families; see A. Bell, R. Chetty, X. Jaravel, N. Petkova, and J. Van Reenen, "Who Becomes an Inventor in America? The Importance of Exposure to Innovation," NBER Working Paper No. 24062 (Cambridge, MA: National Bureau of Economic Research, 2016).

32 X. Jaravel, N. Petkova and A. Bell, "Team-Specific Capital and Innovation," *American Economic Review* 108.4–5 (2018): 1034–1073.

33 M. Dorner, D. Harhoff, T. Hinz, K. Hoisl, and S. Bender, "Social Ties for Labor Market Access: Lessons from the Migration of East German Inventors," IAB–Discussion Paper 41/2016 (Nuremberg: Institute for Employment Research, 2016).

34 O. Toivanen and L. Väänänen, "Education and Invention," *Review of Economics and Statistics* 98.2 (2016): 382–396.

35 P. Aghion, U. Akcigit, A. Hyytinen, and O. Toivanen, "The Social Origins of Inventors," NBER Working Paper No. 24110 (Cambridge, MA: National Bureau of Economic Research, 2017).

36 T. Jung and O. Ejermo, "Demographic Patterns and Trends in Patenting: Gender, Age, and Education of Inventors," *Technological Forecasting and Social Change* 86 (2014): 110–124.

and Ejermo³⁷ offer the Swedish case, matching patent data with demographic information and the Swedish census. They document educational and demographic trends among Swedish inventors, and analyse differences in inventive performance between native and immigrant inventors. One last example involves Italy, where Depalo and Di Addario link EPO patent data with employee/employer administrative records from the Italian Social Security Institute (Istituto Nazionale Previdenza Sociale), resulting in a longitudinal dataset covering the full working history of Italian patenting firms' employees.³⁸ They study inventors' economic returns to patenting, providing evidence of an increase in wages before and during the patenting process, with eventually granted inventions yielding higher gains.

3. Data Treatment, Technical Issues, and Emerging Legal Complications

Applied econometrics research employing inventor statistics requires a thorough treatment of the available data. The main technical issues to be tackled are geolocalisation and disambiguation. Ethnicity assignment of individuals constitutes an additional challenge for studies requiring such information. This chapter briefly overviews each issue, concluding with additional remarks on legal complications emerging from data cleansing and harmonisation procedures.

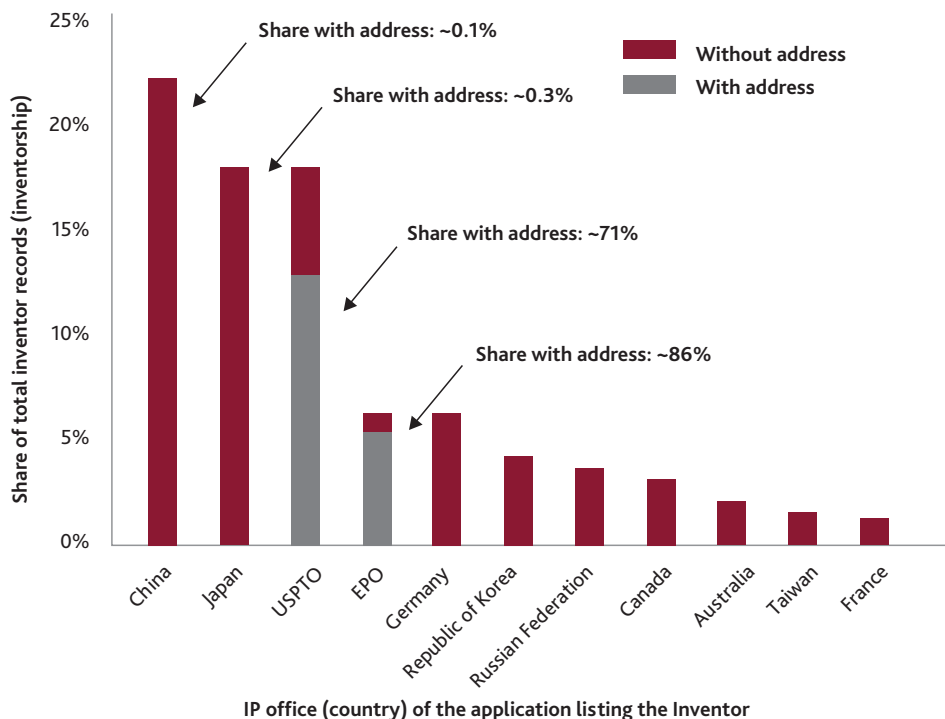
3.1 Geolocalisation

The disclosure of addresses of individuals and entities on patent application documents allows the geolocalisation of the inventors and applicants behind each patent request. Besides being crucial information for any study concerned with the geography of inventive activities, addresses constitute a pivotal attribute of any disambiguation algorithm (see Section 3.2). Unfortunately, the raw information provided by patent data repositories is not seamlessly integrated into researchers' final analyses, mostly due to missing information and data quality issues. These problems arise from the distinct application requirements and data diffusion practices of each national or international IP authority. For instance, USPTO patents often do not report the full addresses of inventors, whose geolocalisation can then take place only at the city or national level.³⁹ Similarly, a few authorities that transmit their data to EPO for inclusion in the DODCB database do not attach the inventors' full addresses, which results in missing observations in PATSTAT. Figure 1 provides an overview of the availability of inventors' addresses according to the IP office where the associated patent application was filed, as evidenced by the latest version of PATSTAT database (Version 2017b). Of the 150 million inventor records available, around 22 percent are associated with patents requested at the State Intellectual Property Office of the People's Republic of China, 18 percent at the Japan Patent Office, 18 percent at the USPTO, and 6 percent at the EPO. The USPTO and EPO have the best coverage,

37 Y. Zheng and O. Ejermo, "How Do the Foreign-Born Perform in Inventive Activity? Evidence from Sweden," *Journal of Population Economics* 28.3 (2015): 659–695.

38 D. Depalo and S. Di Addario, "Shedding Light on Inventors' Returns to Patents," Development Working Papers No. 375 (Milano: Centro Studi Luca d'Agliano, University of Milan, 2014).

39 Morrison et al. document how less than 5 percent of USPTO patent application records offer inventors' addresses with full street information, in contrast to EPO and Patent Cooperation Treaty application data, which include high-resolution addresses (street number, street, postcode) for a large portion of their records; G. Morrison, M. Riccaboni, and F. Pammolli, "Disambiguation of Patent Inventors and Assignees Using High-Resolution Geolocation Data," *Scientific Data* 4 (2017), Online, Article 170064.

Figure 1. Inventors' address coverage by main intellectual property (IP) authority

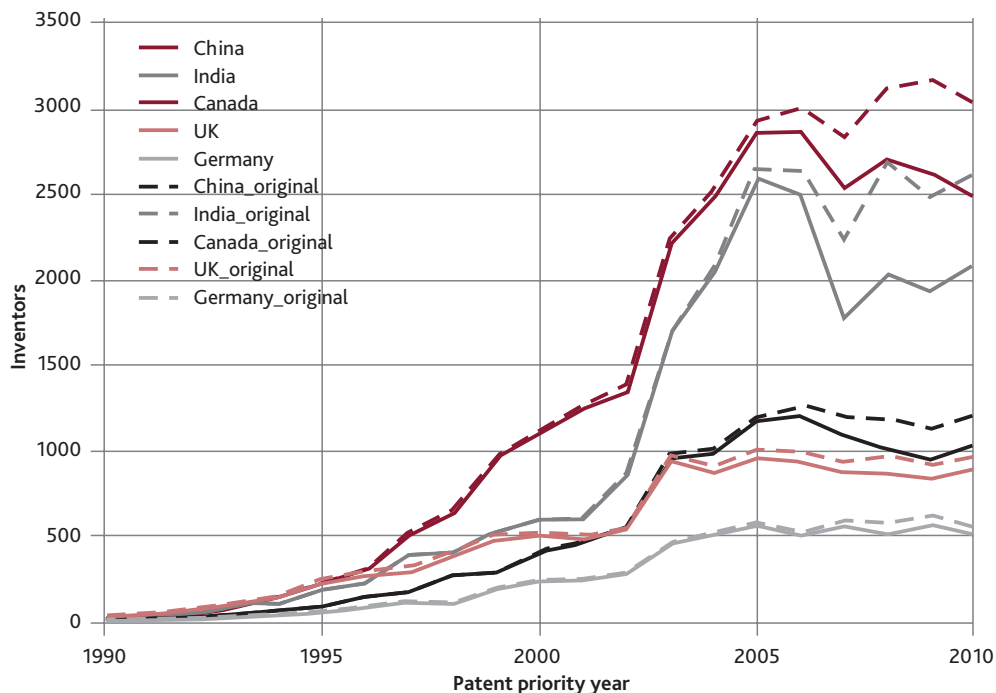
Note: Inventor records correspond to individuals (natural persons) listed on patent applications.
 Source: European Patent Office (EPO) Worldwide Patent Statistical Database (PATSTAT), Version 2017b.

reporting at least a portion of inventors' addresses for 71 percent and 86 percent of their records respectively. Only a tiny fraction of records gathered from applications filed in China and Japan offer the same information (0.1 percent and 0.3 percent respectively), which is in line with poor track records of most other major national patent offices. Inventors' address data also vary in terms of data quality across application authorities.

A feasible methodology to tackle issues of missing information and address quality is to consider patent families.⁴⁰ A large proportion of them exhibit the same team size and often the same inventors across patent applications covering the same invention in different IP jurisdictions. It is thus possible to retrieve inventors' addresses from the applications with available geolocalisation references and match them with their corresponding records within the same patent family.

An additional problem arises when applications do not report the real residence of the inventors, due to applicant-specific patenting procedures. Ferrucci and Lissoni provide evidence in this regard

40 "A patent family is a set of patents taken in various countries to protect a single invention" (Organisation for Economic Co-operation and Development). This feature stems from the "territorial nature of patent protection"; C. Martinez, "Patent Families: When Do Different Definitions Really Matter?" *Scientometrics* 86.1 (2011): 39–63. If an applicant wants to protect an invention in different countries, a request has to be filed at the intellectual property office of each country targeted. The quest for international patent protection is eased by international treaties allowing IP protection to be requested in multiple countries with a single application, e.g. PCT (<http://www.wipo.int/treaties/en/registration/pct/>) and European Patent Convention (<http://www.epo.org/law-practice/legal-texts/epc.html>).

Figure 2. United States main immigrant inventors groups' patenting activity (1990–2010)

Notes: Yearly count of Patent Cooperation Treaty patent applications listing United States-resident foreign inventors. Dashed lines do not account for inventors' flawed addresses. Solid lines exclude inventors whose address coincide with applicant's address. Priority years refer to the earliest filing date among patents in the same sample family.

Source: E. Ferrucci and F. Lissoni, "Foreign Inventors in the US and EU15: Diversity and Productivity," paper presented at the GeoInno2018 Conference, Barcelona, 31 January–2 February 2018, <https://ecm.univ-rennes1.fr/nuxeo/site/esupversions/5bcf50f1-5ba8-44dd-afdd-355e7e9f78a9?inline>

for patents applied for through the Patent Cooperation Treaty (PCT) system.⁴¹ They show how a proportion of their sample's foreign-defined inventors were connected to applicants' corporate addresses (e.g. a firm's headquarters, R&D centre, or subsidiary) or, in a few cases, that of the law firm taking care of the patent application. Figure 2 reveals how accounting for flawed address information changes the magnitude of foreign inventors' patenting activity in the United States.

3.2 Disambiguation

Identification of inventors and applicants is another chief concern. Patent databases contain many entries, often encompassing millions of observations. It is therefore common to encounter homonymy cases, misspelled names, or missing information. This prevents the unique identification of inventors or applicants, since intellectual property authorities do not attribute distinctive codes to either of them. The risk of assigning the same identification code to different entities (i.e. type I errors or false positives) or treating as different two entities that are in fact identical (i.e. type II errors or false negatives) is high, biasing any analysis not properly addressing the issue.

41 E. Ferrucci and F. Lissoni, "Foreign Inventors in the US and EU15: Diversity and Productivity," paper presented at the GeoInno2018 Conference, Barcelona, 31 January–2 February 2018, <https://ecm.univ-rennes1.fr/nuxeo/site/esupversions/5bcf50f1-5ba8-44dd-afdd-355e7e9f78a9?inline>.

Concerning inventor data, researchers have advanced multiple disambiguation techniques in recent years. The most common ones usually involve comparing similar entries (i.e. applications listing inventors with the same or close names) and using additional information to estimate the probability that those records relate to the same individual. Often, they can be described as a three-step process:⁴²

- **Cleaning and parsing:** the relevant text strings (i.e. those containing information on name, surname, and address of the inventor) are purged of typographical errors, while all characters are converted to a standard character set. If necessary, any relevant string is parsed into several substrings, according to various criteria (punctuation, blank spaces, etc.). Typically, the string containing the inventor's complete name is parsed into name, surname, and title (if any). The address is parsed too.
- **Matching:** the algorithm selects pairs of inventors who are likely candidates to be the same person, due to homonymy or similarity of their names.
- **Filtering:** the selected pairs are filtered according to additional information retrieved either from the patent documentation or from external sources. Some typical information from within the patent documentation is the address (e.g. namesakes sharing the same address are believed to be the same person) or some characteristics of the patent. The latter include the patent applicant's name (e.g. homonyms whose patents are owned by the same company may be presumed to be the same person) or its technological contents (as derived from the patent classification system or patent citations).

Alongside early attempts within specific research projects,⁴³ Trajtenberg et al. propose one of the first efforts to explicitly introduce a consolidated disambiguation methodology.⁴⁴ Based on the NBER Patent and Citations Data File,⁴⁵ they uniquely identify roughly 1.6 million inventors worldwide, by pairing similar inventor name entries via a simple-string-match algorithm and then filtering the results through similarity scores based on personal or patent characteristics. The results are benchmarked against a manually assembled sample of uniquely identified inventors. A potential pitfall of this approach concerns the inevitably arbitrary design of thresholds to be met by overall and characteristic-related scores for the matches' validation. Pezzoni et al. counter this issue by means of simulation analysis. They upgrade the "Massacrator©" algorithm⁴⁶ and execute a Monte Carlo simulation against a training dataset, so as to calibrate both the weights assigned to the filtering criteria and the similarity

42 Raffo and Lhuillery test and compare different technical approaches available at each stage of disambiguation processes, using a sample of inventors listed on EPO's PATSTAT database of patent applications. They first present performance scores of individual and combined methodologies in terms of precision, recall, and the balance between the two. They also offer an overview of the biases suffered by econometric inferences that depend on particular matching and filtering algorithms. J. Raffo and S. Lhuillery, "How to Play the 'Names Game': Patent Retrieval Comparing Different Heuristics," *Research Policy* 38.10 (2009): 1617–1627.

43 J. Singh, "Collaborative Networks as Determinants of Knowledge Diffusion Patterns," *Management Science*, 51.5 (2005): 756–770; and L. Fleming, C. King, and A.I. Juda, "Small Worlds and Regional Innovation," *Organization Science* 18.6 (2007): 938–954.

44 M. Trajtenberg, M., G. Shiff, and R. Melamed, "The 'Names Game': Harnessing Inventors' Patent Data for Economic Research," No. w12479 (Cambridge, MA: National Bureau of Economic Research, 2006).

45 B.H. Hall, A.B. Jaffe, and M. Trajtenberg, "The NBER Patent Citations Data File: Lessons, Insights and Methodological Tools," NBER Working Paper No. 8498 (Cambridge, MA: National Bureau of Economic Research, 2001).

46 M. Pezzoni, F. Lissoni, and G. Tarasconi, "How to Kill Inventors: Testing the Massacrator© Algorithm for Inventor Disambiguation," *Scientometrics* 101.1 (2014): 477–504.

threshold. Li et al.⁴⁷ provide an alternative technique, building on the Author-ity project's Bayesian-classifier approach developed by Torvik et al.⁴⁸ and Torvik and Smalheiser.⁴⁹ Through a semi-supervised classification algorithm with an iterative blocking scheme, they avoid the assignment of ad hoc filtering weights and other forms of manual optimisation of the disambiguation procedure. More recently, Morrison et al.⁵⁰ have presented a geolocation-based algorithm that exploits the EPO and PCT databases' high-resolution address information for a simple-string-match procedure, yielding the disambiguation of inventors (and assignees) on about 3.6 million patents found in the EPO, PCT, and USPTO registers.

Scholar-led disambiguation efforts have recently been included in wider institutional projects concerning patent data. An example is the PatentsView initiative supported by the USPTO, aimed at creating an analytical platform for patent data investigation. Its database employs a newly developed disambiguation algorithm,⁵¹ based on a hierarchical co-reference approach and blocking/canopy techniques to achieve higher precision than similar pairwise comparison methods.

3.3 Ethnicity/Nationality Assignment

Migration-and-innovation studies crucially depend on assigning nationality or ethnicity information to inventors. This is not a trivial task, since patent records issued by most IP authorities do not include information on inventors' nationality or place of birth.

A partial exception is provided by the WIPO-PCT dataset, assembled by the World Intellectual Property Organization (WIPO) for all the inventors listed on applications following the PCT procedure.⁵² The database exploits two legal technicalities: first, the PCT procedure requirement for applicants to declare their nationality; second, a peculiarity of the US patent law, which until 2011 admitted only physical people as patent applicants. As a result, patents filed or extended to the USPTO according to the PCT procedure report the nationality of inventors. Unfortunately, the nationality information does not reveal immigrant inventors who have become citizens of the host countries, thereby underestimating migration figures. In addition, the data stop in 2011 and, for earlier years (especially before the mid-1990s), are limited by the limited number of PCT member countries.

In order to obviate these limitations, researchers have thus experimented with name analysis algorithms, mostly based on public name-ethnicity directories. A pioneering strategy in this

47 G.C. Li et al., "Disambiguation and Co-authorship Networks of the US Patent Database (1975–2010)," *Research Policy* 43.6 (2014): 941–955.

48 V.I. Torvik, M. Weeber, D.R. Swanson, and N.R. Smalheiser, "A Probabilistic Similarity Metric for Medline Records: A Model for Author Name Disambiguation," *Journal of the American Society for Information Science and Technology* 56 (2005): 140–158.

49 The Author-ity project achieved a full disambiguation of the PubMed database, a bibliographic repository of the biomedical scientific literature; V.I. Torvik and R. Smalheiser "Author Name Disambiguation in Medline," *ACM Transactions in Knowledge Discovery from Data* 3.3 (2009): 1–30.

50 G. Morrison, M. Riccaboni, and F. Pammolli, "Disambiguation of Patent Inventors and Assignees Using High-Resolution Geolocation Data," *Scientific Data* 4 (2017), Online, Article 170064.

51 N. Monath and A. McCallum, "Discriminative Hierarchical Coreference for Inventor Disambiguation," Presentation, PatentsView Inventor Disambiguation Technical Workshop, USPTO, 2015.

52 E. Miguélez and C. Fink, "Measuring the International Mobility of Inventors: A New Database," WIPO Economic Research Working Papers No. 8 (Geneva: World Intellectual Property Organization, 2013).

direction is provided by Kerr, who combines inventor data (name and surname) from the USPTO with the Melissa ethnic-name database,⁵³ a commercial repository of names and surnames of United States residents, classified by likely country of origin. More recently, Breschi et al. have built on the same approach by experimenting with the IBM-GNR system, a commercial product that associates a list of names and surnames to a likely country of origin.⁵⁴ Nathan exploits instead ONOMAP name classification software,⁵⁵ a naming-network clustering algorithm that assigns likely ethnic groups and other characteristics (e.g. linguistic group) to name–surname combinations.⁵⁶

3.4 Emerging Legal Complications

A side effect of researchers' data cleansing and harmonisation procedures is the identification of potential legal complications, as evidenced by discrepancies or specific patterns among the patent application documents examined. One case relates to the quality of inventor information found on patent application documents. As explained in Section 3.1, some patent applications may report clearly erroneous addresses for a subset of inventors, providing corporate addresses instead of the inventors' personal addresses.⁵⁷ This leads to doubt over the applicants' patenting procedures and the accuracy of the disclosed information. What is the extent of incorrect information on inventors? Does it happen by chance, perhaps due to time constraints or sloppy application practices, or is it a consequence of companies' policies in terms of information diffusion about their employees? Are there underlying strategic motivations not to disclose inventors' real addresses or purposely list incorrect addresses?

Another interesting example has to do with discrepancies between number of authors and inventors in "patent/publication pairs," namely pairs of scientific publications and patents describing the same invention. Both authorship and inventorship are key "attribution rights," namely moral rights upon which individuals may build their professional reputation and careers. Lissoni et al. analyse a sample of related sets of patents and publications, showing how junior and female team members may give up inventorship to secure authorship of articles, even when entitled to both.⁵⁸ Häussler and Sauermann exploit a survey on 2,000 life scientists.⁵⁹ They document how inventorship is determined primarily by substantive contributions (e.g. conception of the idea) and positively associated with higher hierarchical positions within an organisation, in contrast to authorship, which is determined by project participation through technical and laboratory work, and is not influenced by individuals' rank or status.

53 W.R. Kerr, "The Ethnic Composition of US Inventors," HBS Working Paper Series No. 08-006 (Cambridge, MA: Harvard Business School, 2008).

54 S. Breschi, F. Lissoni, and G. Tarasconi, "Inventor Data for Research on Migration and Innovation," in E. Miguélez and C. Fink (eds), *The International Mobility of Talent and Innovation* (Cambridge: Cambridge University Press, 2017).

55 M. Nathan, "Same Difference? Minority Ethnic Inventors, Diversity and Innovation in the UK," *Journal of Economic Geography* 15.1 (2015): 129–168.

56 P. Mateos, *Names, Ethnicity, and Populations: Tracing Identity in Space* (Heidelberg: Springer, 2014).

57 E. Ferrucci and F. Lissoni, "Foreign Inventors in the US and EU15: Diversity and Productivity", paper presented at the GeolInno2018 Conference, Barcelona, 31 January–2 February 2018, <https://ecm.univ-rennes1.fr/nuxeo/site/esupversions/5bcf50f1-5ba8-44dd-afdd-355e7e9f78a9?inline>.

58 F. Lissoni, F. Montobbio, and L. Zirulia, "Inventorship and Authorship as Attribution Rights: An Enquiry into the Economics of Scientific Credit," *Journal of Economic Behavior and Organization* 95 (2013): 49–69.

59 C. Häussler and H. Sauermann, "Credit Where Credit Is Due? The Impact of Project Contributions and Social Factors on Authorship and Inventorship," *Research Policy* 42.3 (2013): 688–703.

4. Research Questions: Inventorship Misallocation and Disclosure

The wide availability of information on inventors, their fields of work, and their geolocalisation has allowed economic research to advance our knowledge on multiple aspects of the technological discovery process. Nevertheless, simple lists of individuals associated with a request for patent protection are mere hints of the complex dynamics underlying an invention's development. As partly evidenced above, a particularly pressing issue involves joint inventorship and the definition of the relative contribution of each scientist or engineer to the invention protected by a patent. Is it possible to discern the role each individual listed as inventor played in the invention's conception?

Referring to legal definitions of co-inventorship might constitute a valid option if it were not for the nuanced and unclear characterisations often provided by national and international patent legislation. In the United States, notions of joint inventorship have been defined as some of "the muddiest concept(s) in the muddy metaphysics of patent law."⁶⁰ Specifically, the US co-inventorship doctrine specifies how an individual can gain inventorship rights by contributing only to a single claim on a patent application.⁶¹ In this case, an important question deals with the identification of the specific claim allowing an individual to be considered as inventor: which claim is it? In other words, which component of the invention can be associated with that specific inventor's ingenuity?

The controversial legal definition of co-inventorship, and the consequent unclear inventorship assignment at the patent application stage, limits possible ex post correction with respect to the true contribution of each individual listed. This might hide bargaining practices among research team members, to the potential detriment of professionals holding less powerful positions within an organisation (see Section 3.4). In addition to individual unfair losses or gains in terms of rights over an invention, inaccurate inventorship assignment offers a biased signal to third parties, such as evaluators, prospective employers, and investors, misled by incorrect information conveyed by patent indicators.

Listing inventors on a patent application might also carry a strategic element, particularly for private enterprises⁶² with a competitive advantage associated to their R&D capabilities. Over two decades of socioeconomic research has established the impossibility of full knowledge codification. The importance of knowledge's tacit dimension, which "can be passed on only by example from master to apprentice,"⁶³

60 W.F. Fasse, "The Muddy Metaphysics of Joint Inventorship: Cleaning Up after the 1984 Amendments to 35 USC § 116," *Harvard Journal of Law and Technology* 5 (1992): 153–208; C.L. Fisk, "Credit Where It's Due: The Law and Norms of Attribution," *Georgetown Law Journal* 95 (2006): 49–117; and E.R. Cohen, "Clear as Mud: An Empirical Analysis of the Developing Law of Joint Inventorship in the Federal Circuit," *Berkeley Technology Law Journal* 28 (2013): 383–415.

61 "The contributor of any disclosed means of a means-plus-function claim element is a joint inventor as to that claim, unless one asserting sole inventorship can show that the contribution of that means was simply a reduction to practice of the sole inventor's broader concept"; *Ethicon Inc. v. United States Surgical Corporation*, 135 F.3d 1456, 1460–63, 45 USPQ2d 1545, 1548–1551 (Federal Circuit, 1998).

62 While the inventors listed on a patent document are in principle the effective owners of the underlying invention—being responsible for the enforcement of their rights over it in case of alleged infringement by third parties—individuals working for a particular organization often share or give up these privileges in their employment contracts to the benefit of the employers.

63 M. Polanyi, *Personal Knowledge: Towards a Post-Critical Philosophy* (London: Routledge, 1958).

makes on-site interactions and face-to-face contacts crucial for the complete transmission of technical know-how.⁶⁴ Scientists' and engineers' mobility between firms thus constitutes a major mechanism for knowledge diffusion, but also a threat to high-tech companies, watching their most valuable assets taking their know-how to competitors.⁶⁵ Inventors' disclosure through patent applications clarifies the targets of rival firms' poaching practices, particularly in the case of highly specialised professionals, leaders of niche fields counting only a handful of experts around the world. These considerations generate precise questions about companies' practices in patenting and disclosing inventors: are companies wary of disclosing their inventors? What rules do they follow in assigning inventorship?

5. Conclusions

Economic research on patent inventors has co-evolved with data availability. On the one hand, it has exploited the increasing amount of data made available to social scientists by IP authorities; on the other hand, it has greatly contributed to steering the data diffusion process, both by soliciting more information and by pioneering new methods for treating and validating it. In doing so, it has raised some substantive issues on the quality of inventor information as reported by patent applicants, deserving the attention of both IP authorities and legal scholars. The former ought to decide whether to enforce more transparency, at the very least for administrative purposes. The latter may wish to open up a reflection on the legal requirements for defining inventorship, and on the extent to which disclosing information on inventor ought to be considered part of the applicant's general disclosure duty. The reflection appears to accord with the well-established evidence on knowledge tacitness (to which economic research on patent inventors has largely contributed), and the consequent need for inventor mobility for knowledge diffusion, above and beyond the free access to patent documentation. Is it consistent to require full disclosure of the invention and then hide or muddle information on inventors, or provide it in the absence of a clear definition of inventorship? Does the lack of accuracy of inventor information aggravate information asymmetry in the labour market for R&D workers, thus making it less efficient? Does it reintroduce secrecy, by making the holders of important pieces of technical knowledge practically unreachable? These questions may sound unfamiliar to European scholars, where the first-to-file granting principle has kept inventors in the shade of applicants, but they may resonate with a US research tradition that, albeit limited, has always dealt with the issue of the identity of inventors.⁶⁶ They will become more important in the future, when computer-implemented inventions will question the need for any physical person to be identified as inventor, as well as inventor-related concepts such as those contained in the notion of non-obviousness.⁶⁷

64 R. Cowan, P.A. David, and D. Foray, "The Explicit Economics of Knowledge Codification and Tacitness," *Industrial and Corporate Change* 9.2 (2000): 211–253; S. Breschi and F. Lissoni, "Knowledge Spillovers and Local Innovation Systems: A Critical Survey," *Industrial and Corporate Change* 10 (2001): 975–1005; and M. Storper and A. Venables, "Buzz: Face-to-Face Contact and the Urban Economy," *Journal of Economic Geography* 4.4 (2004): 351–370.

65 Collateral evidence on the value of highly skilled labour has been given by recent disputes over "post-employment covenants not to compete," the so-called "non-compete agreements." These have been proven to efficiently prevent workers' mobility across firms; see M. Marx, D. Strumsky, and L. Fleming, "Mobility, Skills, and the Michigan Non-Compete Experiment," *Management Science* 55.6 (2009): 875–889. They have been found to be illegally established among incumbents in jurisdictions preventing their application, e.g. Silicon Valley's "no-poaching case," *High-Tech Employee Antitrust Litigation*, U.S. District Court, North. Distr. of California 11-cv-2509, <http://www.cand.uscourts.gov/lhk/hightechemployee>.

66 S.M. O'Connor, "Hired to Invent vs. Work Made for Hire: Resolving the Inconsistency among Rights of Corporate Personhood, Authorship, and Inventorship," *Seattle University Law Review* 35 (2011): 1227–1246.

67 R. Abbott, "Autonomous Machines and Their Inventions," *Mitteilungen der deutschen Patentanwälte* (2017): 429–437; R. Abbott, "Everything is Obvious," *UCLA Law Review*, 2017, <https://ssrn.com/abstract=3056915>.

The emergence of these research questions reveals how economic research on inventors has travelled all the way from making instrumental use of inventor data in investigating economics-specific topics (such as the geography of innovation), to focusing and contributing to IP-specific topics. Along this path, it has crossed and cast light on issues such as the role of IP in science and the relationship between scientific publishing and patenting. The time has come for research on inventors to figure more prominently in the research agenda of IP scholars from both law and economics.

Managing Big Data in the Digital Age: An Industry Perspective

Claudia Jamin

1. Introduction*

The world is changing rapidly and we are facing the fourth industrial revolution, connecting billions of people and innumerable machines around the globe. The magnitudes are increasing by multiples every day, changing our ways of living and working, and our relationships to one another.

While, during the past 250 years, industries 1.0–3.0 led us from the first practical steam engines through elevated conveyer belts for mass production to electronics and software-based controls enabling automated production, industry 4.0 is revolutionising the industrial markets with digital technologies that are driving innovation with tremendous speed. By 2025, disruptive technologies such as the Internet of Things, mobile internet, automation of knowledge work, cloud technology, and advanced robotics—to name just a few—will have a substantial impact on every country, industry, and society.

One of the many results is the massive generation, transfer, storage, processing, and analysing of structured and unstructured data and the creation of big data. Hence, the amount of data is exploding on a daily basis. While less than 10 zettabytes of data were created in 2015, according to the market intelligence company IDC, expectations go as high as 180 zettabytes of data (or 180 trillion gigabytes) in 2025. At the start of 2017, it was predicted that by the end of the year, revenue growth from digital technology-based products would double that of the remaining product/service portfolio for a third of Fortune 500 companies.¹

Beside data volume and velocity, data variety will become one of the most important value drivers adding valuable content to the so-called big data collected from human beings and machines. The big data market is expected to grow worldwide from US\$ 33.5 billion in revenue for 2017 to US\$ 88.5 billion in 2025.² Hence, investment by software, content, and database providers in the development of products and services such as software, databases, and platforms for generating, processing, and storing big data will continuously increase. The product and system industries and markets have also recognised the value of big data and its role in the creation of new products and services, as well as improvements in existing ones.

2. ABB and Digitalisation

ABB is a global leader in power and automation technologies, operating in more than 100 countries. It provides a wide range of industry-leading solutions to its customers in various markets, which are increasingly developed based on the collection and processing of relevant data on a common technology platform. This platform is a set of reusable technical components and will allow ABB's solutions to be deployed on the premises, in the cloud, and between clouds. The economic impact

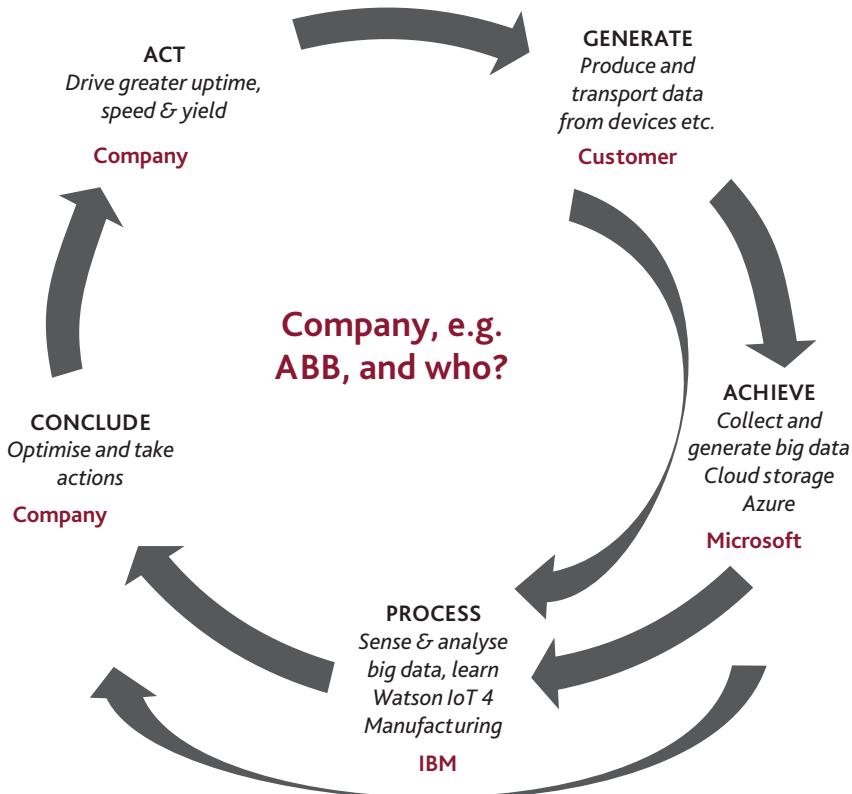
* The views and opinions expressed in this chapter are those of the author and do not necessarily reflect the official policy or position of the ABB group or any single ABB entity. Examples created, analyses performed, and assumptions within this chapter are made by the author and are not reflective of the ABB Group or any single ABB entity. All information used in this chapter is publicly available information.

1 Gil Press, "6 Predictions for the \$203 Billion Big Data Analytics Market," *Forbes*, 20 January 2017, <https://www.forbes.com/sites/gilpress/2017/01/20/6-predictions-for-the-203-billion-big-data-analytics-market/#9c4845820838>.

2 "Forecast of Big Data Market Size, Based on Revenue, from 2011 to 2026," *Statista*, <https://www.statista.com/statistics/254266/global-big-data-market-forecast/>.

occurs in terms of improvements in productivity or cost reductions. The value will increasingly move from physical products to those enabled by digital technologies (software and connectivity). ABB is a key player in many of these markets, such as the Internet of Things (power grids, industrial automation), cloud technologies (using cloud software and supplying data-centre electrical equipment), the electrification of transportation, advanced oil and gas exploration, and supplying inverters and supervisory control and data acquisition (SCADA) systems for renewable energy (for example, ABB's microgrid systems). ABB Ability™ refers to both a set of industry digital solutions and the platform they are built on. ABB is building the platform from the top industry technologies, such as Microsoft's Azure cloud services, IBM Watson's machine learning and artificial intelligence, and SAP HANA's big-data query tools, which in various ways collect, store, and process big data.³ These innovative technologies require continuing investment and partnerships with the relevant players in the market. Figure 1 shows a simplified example of possible data flows and processing to and from the customer, and involving ABB, with the question at the centre of who owns the data.

Figure 1. Simplified example of possible data flows and processing, and the ownership question at its centre



3 ABB, "ABB and Microsoft Partner to Drive Digital Industrial Transformation," press release, 4 October 2016, <http://new.abb.com/news/detail/245/abb-and-microsoft-partner-to-drive-digital-industrial-transformation>; and ABB, "ABB and IBM Partner in Industrial Artificial Intelligence Solutions," press release, 25 April 2017, <http://new.abb.com/news/detail/1411/abb-and-ibm-partner-in-industrial-artificial-intelligence-solutions>.

Figure 1 shows just one example of many possible data flows and processes. Whether through this or any other structuring, it becomes clear that various stakeholders with different tasks participate in the overall setup. There is one interest they all have in common: big data. And this common interest immediately raises the question: who owns the big data in such a data life cycle? Can big data be owned at all?

These questions trigger particular challenges to a company's intellectual property management in a fast-changing technology environment. Legislation is not necessarily harmonised and might be contradictory, possibly even competitive. What does the legal environment provide to enable a company to protect its investment in digital technologies based on big data?

3. Intellectual Property Rights and Data Ownership in Europe

Due to the rapidly increasing value of the data market, investing companies are seeking legal mechanisms to protect and ensure ownership in (big) data. To start with, at present neither European Union (EU) nor national legislation directly regulates the ownership of big data in an adequate manner. Though there is much legislation, including criminal law, competition law, and data privacy protection, as well as case law, that has an impact on and provides indications for certain ownership-like situations, the legislative environment remains inconsistent and cannot provide resilient solutions to secure the enormous investment by companies in the new big-data based technologies.

The nature of the industry relating to power and automation technologies, where companies like ABB are operating, means that the intellectual property rights landscape is possibly the most relevant framework for data ownership protection. Hence, the following will trigger some further thoughts on the incentives for companies to invest in data technologies in light of EU and national legislation in Europe relating to copyright, database rights, and trade secrets.

3.1 Copyright Protection

The most obvious intellectual property right to address data ownership seems to be copyright. While copyright protection is regulated by national law, the good news is that international treaties provide at least some harmonisation and protection.⁴ However, the impact of diverse national laws within Europe remains substantial since there is still no synchronised legal framework.

In any case the question arises as to whether big data in an ABB-like business in particular qualify for ownership under the general principles of copyright, irrespective of any national peculiarities. While in principle copyright legislation might provide some ownership protection to the author of (big) data in that it covers created works of different types, it does require in the first place that there is an author who created such data—that is, it requires intellectual and intentional human creation to accomplish the copyright-protected results. In the field of power and automation technologies, however, data are generated mostly (if not exclusively) by machines, apparatuses, gears, engines, motors, and systems—referred to in the following as device(s)—of various types that continuously but certainly not consciously produce data. Hence, the creative act of authorship is highly doubtful and mostly not recognised in European jurisdictions.

⁴ Berne Convention (1886), Universal Copyright Convention (1952), Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) (1994), World Copyright Treaty (1996), and Directive 2001/29/EC of the European Parliament and of the Council on the Harmonisation of Certain Aspects of Copyright and Related Rights in the Information Society (2001).

But aside from that, who could be considered to be the author and thus the owner? There are several players involved in the entire life cycles of data who could possibly claim such ownership rights. One of them is the owner of the device that produces the data. Such data result from specific operational patterns, representing how and when the device is used, and hence the device produces individual, user-related data leading back to the owner. It could be argued, however, that those data, though related to the use of the device, basically result from the technology that is incorporated into such devices, usually owned by the manufacturer. The data might be established as part of the know-how related to such technology. The manufacturer of the devices might therefore claim ownership of these data. In the case of the example shown in Figure 1, another stakeholder certainly would be the cloud and/or platform provider, since the data accumulate and create at least a new set of big data right there. Or possibly all of them together, especially when it comes to the creation of big data from different sources? And how can data ownership in the context of big data be proven if the generation of the data includes multiple sources? The answers to these questions are not a given and, if they are not clarified by legislation, it remains to be seen how case law will deal with these questions. In the absence of clear legislation, it might also be up to the individual parties—that is, device manufacturers, “users,” “customers,” and so on—to find bilateral agreements on how to handle the matter.

Another aspect relates to the requirement of originality under copyright protection. While it could protect many types of data, which would cover a wide range of artificially generated data, those data would need to be original. Originality is the differentiator from pure reproductions, repetitions, copies, and so on, and thus ensures protection of new or novel creations. This may become an issue, particularly when it comes to the creation of the same data from numerous similar devices. At least at the level of such data sources, originality might be problematic and needs to be assessed on a case-by-case basis. The requirement of originality also closes the circle with the question of authorship, as it is supposed to reflect the author's personality in making free and creative choices in the work with the author's own fingerprint. No need to mention that a machine fails on this condition.

It is not only eligibility for copyright as such that raises questions, but also the territoriality of legislation. This concerns the applicability of national law in European countries with different ranges of protection and the rather low level of harmonisation on an international minimum. Depending on their operational coverage, global companies like ABB need to deal with many different and divergent legislative regimes with diverse requirements and legal security. Given the need for data protection and the level of synchronisation of national laws at present, international companies are obliged to adjust their business models to safeguard nationally available protection, and so their investments in the digital world. Nevertheless, accumulation and consolidation of (big) data need to take place at some point, and somewhere, to develop and exploit the full value of (often locally generated) data. This will finally reshuffle again the potential business solutions for protection and ownership.

3.2 Database Protection

Since big data are usually collected, stored in, and possibly processed by databases, they might be protected within the scope of database protection. The European Database Directive addresses the legal protection of databases in any form,⁵ defining a database as “a collection of independent works, data or other materials arranged in a systematic or methodical way and individually accessible by

5 Directive 96/9/EC of the European Parliament and of the Council of 11 March 1996 on the Legal Protection of Databases, Article 1.

electronic or other means." This results in the independent protection of databases by copyright and by sui generis right. So far, so good.

Database protection under copyright can in accordance with the Database Directive be achieved when the database is the result of the author's own intellectual creation leading back to the general principle of originality under copyright law. In the context of database creation, originality may result (again) from the free selection and creative arrangement of the data to be stored in such databases. The prerequisite of originality, however, cannot be fulfilled where the collected data are continuously transmitted by devices to the databases without any human contribution. In other words, can an underlying algorithm managing the content and structure of a database by automatically generated data replace individual authorship and therewith create originality? Or should copyright be granted rather to the algorithms that create the databases because of their own original content instead of the data content as such?

Following the nature of copyright, intended to support human creativity in the arts and sciences, as well as the regulatory background of the Database Directive, databases automatically created by platforms generating continuously (and uncontrolled) data content cannot be protected by database protection based on copyright due to the lack of people (whether natural or legal) creating the databases.

As mentioned, the Database Directive also foresees a sui generis right "for the maker of a database which shows that there has been qualitatively and/or quantitatively a substantial investment in either the obtaining, verification or presentation of the contents to prevent extraction and/or re-utilization of the whole or of a substantial part, evaluated qualitatively and/or quantitatively, of the contents of that database."⁶ The bad news is that the database protection sui generis requires substantial investment in the creation of the database as such. This investment is irrespective of the data that become the content of such databases. Hence, individual data as such are not fully protected.

3.3 Trade Secret Protection

Contrary to the copyright and database protections, trade secret protection focuses on the secrecy of commercially valuable information and data, including any kind of know-how developed and owned by the (natural or legal) person. The international legal framework can be found in the Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement and the Trade Secrets Directive.⁷

While the protection of trade secrets does not require any particular data types or originality, and hence also allows the protection of individual data for an unlimited time, the immanent trade secret condition of secrecy may create protection issues for companies like ABB that need to use these data. Issues may occur for two different aspects of secrecy: (1) the use of (big) data as such, if secret; and (2) the establishment and maintenance of trade secrets to achieve the desired protection.

In ABB's industrial environment, large quantities of data are collected to develop products and services providing customers with greater uptime, speed, and yield, eliminating inefficient processes

6 Directive 96/9/EC of the European Parliament and of the Council of 11 March 1996 on the Legal Protection of Databases, Article 7.

7 Directive (EU) 2016/943 of the European Parliament and of the Council of 8 June 2016 on the Protection of Undisclosed Know-how and Business Information (Trade Secrets) against Their Unlawful Acquisition, Use and Disclosure.

and redundant tasks, and ensuring accuracy, precision, and consistency. If these data are kept secret, then working with them and using them for the purposes of product and service development become quite challenging. And even if secrecy of the data at stake is a part of the business model, the necessary measures to ensure and prove secrecy are quite demanding for multinational enterprises operating and serving customers around the globe.

4. Additional Considerations

The digitalisation and data industry is rapidly changing the landscape of the relevant industry players. The capital-intensive hardware industry remains solid but is also a source of moderate innovation and growth. Often it is outsourced to low-cost countries to remain competitive. In turn, new players are entering the market of power and automation technologies covering the digital side of the industry. These new players are already experienced in similar technologies and extremely fast in adapting to change and innovation. While enterprises in the product and systems industries are in the process of adjusting their organisational structures, today's suppliers of cloud services, databases, and software solutions are transforming into competitors in the same market, increasingly touching and overlapping with the product portfolio. Though there is the legal option to regulate data (and other intellectual property) ownership in the contracts, daily practice has shown that negotiations become more and more challenging, time-consuming, and costly. Both partners need to decide what they want to own, what they can own, and what they need to own, and will not hesitate to enforce their interests. The winner will be the one who can survive without the other.

5. Conclusion

There is diverse EU and European national legislation that impacts the ownership of (big) data. However, consistent and resilient solutions for data protection and ownership are missing. While intellectual property rights such as copyright, database protection, and trade secrets may provide certain benefits on a case-by-case basis, the legal environment remains insecure for companies investing huge amounts in the development of new technologies. In addition, the rapid growth of the digital market and the speed of technology development suggest the need for another review of the legal environment within the EU and in relation to other jurisdictions to ensure a return on investments and competitiveness in Europe.

CEIPI–ICTSD Global Perspectives and Challenges for the Intellectual Property System

- Rethinking International Intellectual Property Law: What Institutional Environment for the Development and Enforcement of IP Law? (Issue No. 1 – November 2015)
- Specialised Intellectual Property Court: Issues and Challenges (Issue No. 2 – March 2016)
- Intellectual Property and Access to Science and Culture: Convergence or Conflict? (Issue No. 3 – December 2016)
- Current Alliances in International Intellectual Property Lawmaking: The Emergence and Impact of Mega-Regionals (Issue No. 4 – August 2017)
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